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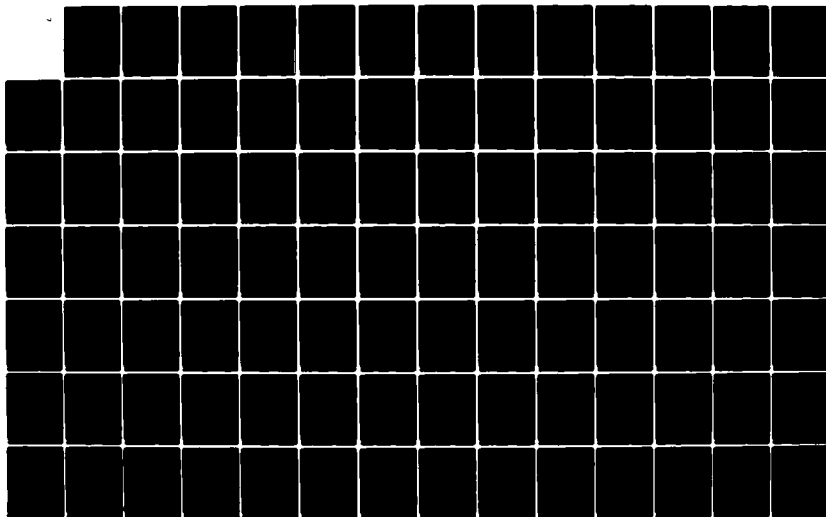
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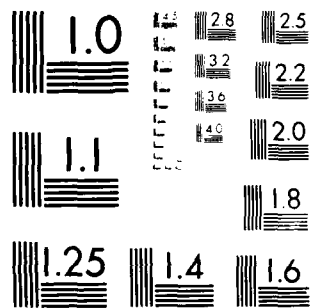
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Biological Effects of Nonionizing Electromagnetic Radiation

Volume VIII, Number 1

October 1983

A Digest of Current Literature

A Quarterly Publication Produced for
Office of Naval Research

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exposure duration and regime, and end point are included in each abstract.

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Block 6. Performing Organization Report Number. Only numbers other than the official report number shown in Block 1, such as series numbers for in-house reports or a contractor/grantee number assigned by him, will be placed in this space. If no such number is used, leave this space blank.

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Block 10. Program Element, Project, Task Area, and Work Unit Numbers. Enter here the number code from the applicable Department of Defense form, such as the DD Form 1498, "Research and Technology Work Unit Summary" or the DD Form 1634, "Research and Development Planning Summary," which identifies the program element, project, task area, and work unit or equivalent under which the work was authorized.

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Block 20. Abstract. The abstract should be a brief (not to exceed 200 words) factual summary of the most significant information contained in the report. If possible, the abstract of a classified report should be unclassified and the abstract to an unclassified report should consist of publicly-releasable information. If the report contains a significant bibliography or literature survey, mention it here. For information on preparing abstracts see "Abstracting Scientific and Technical Reports of Defense-Sponsored RDT&E," AD-667 000.

**Biological Effects
of Nonionizing Electromagnetic Radiation**

A Digest of Current Literature

**A Quarterly Publication Produced for
Office of Naval Research**

*Literature Selected and Abstracted
by*

*Information Ventures, Inc.
1500 Locust Street
Philadelphia, Pa 19102*

Bruce H. Kleinstein, Ph.D., J.D., Project Manager

"The views and conclusions contained in this documentation are those of the author and should not be interpreted as necessarily representing the officials' policies, either expressed or implied, of the Office of Naval Research."

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Biological Effects of Nonionizing Electromagnetic Radiation

October, 1983 Volume VIII, Number 1

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Preface

Biological Effects of Nonionizing Electromagnetic Radiation is a publication researched and prepared by Information Ventures, Inc. under contract to the Office of Naval Research.

This digest serves as a vehicle through which current documentation of research highlights on the biological effects and health implications of nonionizing electromagnetic radiation (microwave and other radio frequency radiation) is compiled, condensed, and disseminated on a regular basis. The effects of electric and magnetic fields (static and alternating) and research on medical applications of these nonionizing electromagnetic radiations are also included.

Biological Effects of Nonionizing Electromagnetic Radiation is intended to be a highly useful current awareness tool for scientists engaged in research or related activities. The great number and diversity of relevant publications make imperative the availability of the service to persons whose work requires that they keep abreast of current developments in the field.

Biological Effects of Nonionizing Electromagnetic Radiation is published quarterly. The issues of Volume VII and future volumes will include materials received during the preceding three months. Each issue contains abstracts of current English and foreign-language research literature, current research summaries, news items and announcements, and information on relevant meetings and conferences. Subject and author indices are provided for all literature abstracts to facilitate specific search and reference use. Journals, books and conference proceedings are used as sources for this publication. Materials for which full text is not available will be included as summary abstracts. Announcements and other materials submitted for publication should be addressed to: Dr. Bruce H. Kleinstein, Information Ventures, Inc., 1500 Locust Street, Philadelphia, PA 19102.

The digest was first published in 1974 under the title "Biological Effects of Electromagnetic Radiation." Since 1976 it has been published under the present title. Previous issues can be obtained from the National Technical Information Service.

Abbreviations and Acronyms

A, amp - ampere	min - minute(s)
C - centigrade	mo - month(s)
cm - centimeter(s)	n - nano-
cps - cycles per second	NIH - National Institutes of Health
dB - decibel(s)	NIOSH - National Institute for Occu- pational Safety and Health
EPA - Environmental Protection Agency	NTIA - National Telecommunications and Information Administration
eV - electron volt	NTIS - National Technical Information Service
F - fahrenheit	Oe - oersted(s)
FAA - Federal Aviation Administration	OSHA - Occupational Safety and Health Administration
FDA - Food and Drug Administration	rad - radiation absorbed dose(s)
g - gram(s)	R - roentgen(s)
G - gauss	rpm - revolutions per minute
GHz - gigahertz	sec - second(s)
HHS - Department of Health and Human Services	sc - subcutaneous
hr - hour(s)	USAF/SAM - U. S. Air Force School of Aerospace Medicine
Hz - hertz	V - volts
ip - intraperitoneal	VA - Veterans Administration
ISM - industrial, scientific, medical	W - watt(s)
IU - international unit(s)	WHO - World Health Organization
iv - intravenous	wk - week(s)
J - joule(s)	wt - weight
k - kilo-	x - times
l - liter(s)	yr - year(s)
m - meter(s)	
m - milli-	
M - mega-	
u - micro-	

NEWS ITEMS

EPA RF/MW BIOEFFECTS REPORT

The EPA's draft report on the biological effects of radiofrequency/microwave radiation will undergo revision with respect to its assessment of thermal risk. The Science Advisory Board Subcommittee met on September 22-23, 1983, at EPA Headquarters in Washington, DC to discuss the draft report. Revisions are expected to be completed by December 83. Copies of the draft report may be obtained from David Janes, Office of Radiation Programs, EPA Headquarters, 401 M Street, SW, Washington, DC; (703)557-8217. Minutes for this meeting can be obtained by contacting Dr. Terry F. Yosie, Director, Science Advisory Board (202)382-4126 or Dr. Douglas Seba, Executive Secretary, Science Advisory Board (202)382-2552. A transcript of the entire proceedings is available for \$0.40 per page from the Executive Court Reporters, 8525 Colesville Road, Silver Spring, MD 20910; (301)565-0054. The transcript is approximately 300 pages.

CRITICAL APPRAISAL OF THE BIOLOGICAL EFFECTS DUE TO EXPOSURE TO ELECTRIC AND MAGNETIC FIELDS AT LOW FREQUENCIES

Contract 68-02-3845. The Environmental Protection Agency, Research Triangle Park, NC has contracted with the National Council on Radiation and Measurements, 7910 Woodmont Avenue, Suite 1016, Bethesda, MD 20814 for the above study.

Commerce Business Daily, October 18, 1983

COMPUTER MODELLING OF 60 HZ ELECTRIC FIELD COUPLING TO BIOLOGICAL TISSUE

Sol DE-RP01-84CE76236. The U.S. Dept. of Energy is seeking proposals from qualified organizations for the above study. Proposals are due by 11/16/83.

Commerce Business Daily, October 14, 1983

THEORETICAL AND NUMERICAL STUDIES OF AN INTENSE MICROWAVE SOURCE

The Naval Research Laboratory, Washington, DC, is negotiating with Science Applications, Inc. McLean, VA 22102 for the above study.

Commerce Business Daily, July 29, 1983

HYPERTHERMIA QUALITY ASSURANCE PROGRAM

Contract N01-CM-37512. The National Cancer Institute has contracted with Allegheny-Singer Research Corp., 320 East North Ave., Pittsburgh, PA 15212 for the above five year incrementally funded study. Commerce Business Daily, July 7, 1983

NEW BOOKS:

NUCLEAR MAGNETIC RESONANCE IMAGING: BASIC PRINCIPLES. Young, Stuart W. 176 p., 80 figures, \$19.00 (November 1983) ISBN 0-89004-998-X. Published by Raven Press, NY, NY

ALL-UNION SYMPOSIUM IN PUSCHINO

An All-Union Symposium on the "Biological Effects of Electromagnetic Fields" was held in Puschino, USSR, in 1982. One hundred sixty eight papers were presented in the following areas: I. Biological Effects of Radio Frequency Electromagnetic Radiation (40); II. Biological Effects of Millimeter-Band Electromagnetic Radiation (14); III. Biological Effects of Low-Intensity Electromagnetic Fields (20); IV. Biological Effects of Constant Magnetic Fields (30); V. Biological Effects of Electric Fields (11); VI. Clinico-Hygienic Aspects of Electromagnetic Radiation (29); VII. Effects of Combined Exposures (10); and VIII. Physical Fields of Biological Materials (14). Figures in parentheses indicate the number of papers presented in each category. Translated titles and author names will appear in the next issue of the Digest. Author affiliations include:

DUBNA

- Joint Inst. Nuclear Research

IVANO-FRANKOVSK

- Medical Inst.

KARAGANDA

- State Medical Institute

KAZAN

- Res. Inst. Traumatology and Orthopedics

KHARKOV

- Res. Inst. Industrial Hygiene and Occupational Diseases

KIEV

- P. M. Buiko Res. Inst. Pediatrics, Obstetrics and Gynecology
- A. N. Marzeev Inst. General and Communal Hygiene
- Inst. Molecular Biology and Genetics, Ukrainian

News Items

- SSP Acad. Sciences
- A. V. Palladin Inst. Biochemistry, Ukrainian SSR Acad. Sciences
- Inst. Microbiology, Virology, Parasitology
- T. G. Shevchenko Kiev State Univ.

KUPAUNA

- Res. Inst. Biological Testing of Chemical Compounds

LENINGRAD

- A. A. Tkhtomskii Physiological Inst.
- Sanitary-Hygienic Medical Inst.
- E. P. Konstantinov Inst. Nuclear Physics
- Res. Inst. Industrial Hygiene and Occupational Diseases
- Res. Inst. Radiation Hygiene

MAKHACHKALA

- Dagestan Polytechnical Inst

MINSK

- Belorussian State Inst. Advanced Medical Training

MOSCOW

- All Union Res. Inst. Cable Industry
- All Union Res. Inst. Electric Current Sources
- A. N. Sysin Res. Inst. General and Community Hygiene
- Inst. Higher Nervous Activity and Neurophysiology
- Inst. Medico-Biological Problems
- Central Res. Inst. Balneology and Physical Therapy
- Inst. Radio Engineering and Electronics
- All Union Cancer Res. Center
- Inst. Biophysics, USSR Ministry Public Health
- Res. Chemical Physics, USSR Acad. Sciences
- Inst. Biological Physics Pushchino, Moscow Region

ST. PETERSBURG

- Res. Inst. Medical Radiology

ROSTOV-ON-DON

- Res. Onkological Inst.

SARATOV

- State Univ.

SIMFEROPOL

- M. V. Frunze State Univ.

TOMSK

- Res. Inst. Biology and Biophysics, State Univ.
- Polytechnical Inst.

VLADIVOSTOK

- Medical Inst.

*Proceedings of the Workshop on Electromagnetic
Fields and Health, October 1983*

WORKSHOP ON ELECTROMAGNETIC FIELDS AND ELECTROMAGNETIC INTERACTIONS WITH LIFE

On November 7-9, 1983, a Workshop was held at the University of Maryland, College Park, Campus. The Workshop was sponsored by the U.S. Office of Naval Research and the Bureau of Radiological Health of the U.S. Food and Drug Administration. The purpose of the meeting was to promote exchanges between researchers in this field and those in other closely related disciplines, provide a forum for critical assessment of theoretical ideas, and to identify problem areas and research priorities. The two and one-half day program included a dozen invited tutorial lectures from leading authorities in their fields, a poster session for contributed papers, and a general review and discussion session. Although the proceedings of the meetings will not be published, it is expected that a short report will be prepared which will attempt to summarize the principal ideas presented at the Workshop and will include the abstracts of the poster papers.

MEETINGS AND CONFERENCES

5th COURSE
BIOLOGICAL EFFECTS AND DOSIMETRY OF NON-IONIZING
RADIATION: STATIC AND ELF ELECTROMAGNETIC FIELDS

Date: November 15-25, 1983

Place: Erice, Italy

Requests for Information: Persons from Europe wishing to attend the course should write to Professor Martino Grandolfo, Istituto Superiore di Sanita, Viale Regina Elena 299, 00161 Rome, Italy; persons from other continents should write to Professor Sol M. Michaelson, The University of Rochester, Medical Center, 601 Elmwood Avenue, Rochester, NY 14642. Closing date for application is September 15, 1983. Fee: \$500 (covers full board and lodging). Content: Part of the course will be devoted to studies, both of a theoretical and experimental nature, relating to potential mechanisms of interaction of static and ELF electromagnetic fields with biological systems. After a detailed review of the fundamentals of physics and biology connected with the interaction of these fields with living matter, the lectures will provide an updating of the techniques developed for the detection and the dosimetry of these energies and a critical analysis of their biological effects in relation to the establishment of safety standards.

RADIATION AND ENERGY: CONFRONTING THE CHALLENGES
OF THE EIGHTIES - LAW, REGULATION, RISK LIABILITY,
LITIGATION AND COMPENSATION

Date: December 8-9, 1983

Place: New York, NY

Requests for Information: James Lawrence, Lloyd's of London Press, 817 Broadway, New York, NY 10003; (212)673-4700

8TH ANNUAL IEEE INTERNATIONAL CONFERENCE ON
INFRARED AND MILLIMETER WAVES

Date: December 12-17, 1983

Place: Carillon Hotel, Miami Beach, FL

Requests for Information: Dr. K. J. Button, National Magnet Laboratory, Building NW-14, MIT, Cambridge, MA 02139; (617)253-5561

MICROWAVE SIGNATURES IN REMOTE SENSING

Date: January 16-20, 1984

Place: Toulouse, France

Requests for Information: Dr. Richard Moore, Remote Sensing Laboratory, Univ. of Kansas, Center for Research, 2291 Irving Hill Drive, Lawrence, KS 66045; (913)864-4836.

SYMPOSIUM ON NMR IMAGING

Date: January 27-29, 1984

Place: Fontainebleau Hotel, Miami Beach, FL

Requests for Information: American College of Radiology, 6900 Wisconsin Ave., Chevy Chase, MD 20815; (301)654-6900.

28TH ANNUAL MEETING OF THE BIOPHYSICAL SOCIETY

Date: February 19-23, 1984

Place: San Antonio Convention

San Antonio, TX

Requests for Information: Biophysical Society, 9650 Rockville Pike, Bethesda, MD 20814; (301)493-6114

BIOLOGICAL EFFECTS OF ELF ELECTROMAGNETIC FIELDS
AND THERAPEUTIC APPLICATIONS

Date: February 23-25, 1984

Place: Venice, Italy

Requests for Information: Dr. Luigi Zecca, Associations for Biomedical Applications of Electromagnetism, Via Gentilino, 9/A, 20136 Milano, Italy; Tel. 02-8321655 or 8391867

Content: Topics of the meeting will be the physical aspects, the biological effects, the medical implications and the therapeutic applications of extremely low frequency (ELF) electromagnetic fields. Attention will be focused on the following items: Physics: field generation devices, field characterization, dosimetry; Biology: cellular effects, developmental effects, physiology, hematology, immunology, neurology, tissue-vascular relationships; and Therapeutics: rheumatology, traumatology, angiology, dermatology, neurology. Abstracts in English must be submitted by December 31, 1983.

Invited lectures by W. R. Adey, V. M. Bogolubov, G. Cheng, J. M. R. Delgado, R. W. Farndale, F. Lechner, A. R. Liboff, V. V. Poltoranov, and L. Zecca

Fee: Registration will be \$150 up to December 31, 1983. Late registration will be \$180.

Publications: An abstract book will be provided to all registered participants. The proceedings will be published by an International Publishing House.

Meetings and Conferences

Biological Effects of Non-ionizing
Radiation VIII-1, October 1984

SIXTH INTERNATIONAL CONGRESS OF THE RADIATION PROTECTION ASSOCIATION

Bank Street, Gaithersburg, MD 20878

Date: July 1-5, 1984
Place: International Congress Center, Berlin,
Germany (DDR)
Sponsor: Int. Radiation Protection Assn. (IRPA)
Request for Information: R. Neider, Sec. General,
Institute for Material Physics, Peter Den
Hofstr. 57, D-1000 Berlin 45, Germany (DDR)
Program: The scientific sessions of the congress
and the exhibits cover all aspects of radiation
protection from basic research to practical appli-
cations with special emphasis on the risk assess-
ment from ionizing and non-ionizing radiation as
well as the risks derived from all other man-made
sources. Papers in English, French, and German.

EIGHTH INTERNATIONAL BIOPHYSICAL SYMPOSIUM

Date: July 29 - August 4, 1984
Place: Bristol, United Kingdom
Sponsor: Int. Union of Pure & Applied Physics
Requests for Information: Dr. B. G. Wainman,
Dept. of Biochemistry, The University, Bristol, Avon,
United Kingdom

4TH INTERNATIONAL SYMPOSIUM ON HYPERTHERMIC ONCOLOGY

Date: July 2-6, 1984
Place: Aarhus, Denmark
Requests for Information: Jens Overgaard, M.D.,
Department Chairman, The Institute of Cancer Re-
search, Artillerivej 65, DK-8000 Aarhus C, Denmark

Date: August 29 - September 7, 1984
Place: Florence, Italy
Sponsor: URSI
Requests for Information: Contact Dr. G.
Rosenthal, Polytechnic Institute of Brooklyn,
110, Farmingdale, NY 11735
Note: A joint meeting with the Biophysical
Society is tentatively scheduled for August 29-31, 1984.

BIOELECTROMAGNETICS SOCIETY SIXTH ANNUAL MEETING

Date: July 12-17, 1984
Place: Omni Hotel, Atlanta, GA
Sponsor: Bioelectromagnetics Society
Requests for Information: BEMS Headquarters, 1

MEETING OF THE EUROPEAN SOCIETY THEORETICAL RADIOLOGY AND ELECTROMAGNETICS

Date: September 9-15, 1984
Place: Jerusalem Hilton, Jerusalem, Israel
Sponsor: KENES
Requests for Information: Prof. Z. Foss, Head,
Dept. of Radiation and Oncology, Hadassah Medical
Center, Jerusalem, Israel

CURRENT RESEARCH

TRANSLATIONS FROM FOREIGN LITERATURE

From time to time, Information Ventures, Inc. will prepare full-text translations of foreign research efforts on the biological effects of nonionizing electromagnetic fields for publication in this Digest. The second of these translations is presented below. It is an excerpt from the following article:

BIOLOGICAL EFFECTS OF MICROWAVE RADIATION. (Hun.) Almássy, Gy. (Scientific Council, TKI - Telecommunications Research Inst. - Hungary); Szabó, L.; Ballai, L. *A Tavközlési Kutató Intézet Közleméyei*, Vol. 27(1-2):15-45; 1982 (46 refs).

Literature data on the biological effects of microwave radiation are reviewed. The discussion covers the physical properties of microwave radiation, its absorption by living organisms, and systemic effects of microwave radiation. Microwave thermography for medical diagnostic purposes is described and apparatus for centimeter- and millimeter-wave thermographic examinations is illustrated. The draft of a new Hungarian microwave radiation safety standard is presented.

..... "In the draft of the new Hungarian standard, different safety regulations are specified for the general population and for persons who are occupationally exposed to microwave radiation. The permissible exposure level for occupationally exposed persons can be higher by 10 dB than that for the general population. Occupationally exposed personnel must undergo periodic medical check examinations.

In the draft of the standard, occupationally exposed persons are defined as follows:

- persons operating, repairing, and measuring equipment emitting electromagnetic energy, who are adequately trained;
- persons using and operating energy-generating equipment who are adequately trained for these tasks;
- persons who are at the site of equipment radiating electromagnetic energy during performance of their jobs, regardless of professional training.

Permissible radiation levels in the draft of the Hungarian radiation safety standard are summarized in Table I, below. The safety levels shown in the table are averages. No distinction is made between exposure to continuous wave or pulse modulated signals. The levels in the table are illustrated in Figures 13, 14, 15, and 16 (from the article).

During extraordinary work conditions, occupationally exposed persons can stay in areas with a high-frequency radiation hazard for a short time period (maximum of 20 minutes) and can perform work. Protective apparatus to be used is specified in separate regulations. To reduce the harmful effects of

the microwave field, protective goggles absorbing microwave energy must be worn.

Radiation safety regulations of the socialist countries are summarized in Table II. "

The measurement of microwave radiation is discussed.

Table I.

Frequency range	0.03-30 MHz	30-300 MHz	0.3-300 GHz
Lower limit values of hazardous radiation			
General population	20 V/m	10 V/m	0.01 mW/cm ²
Occupational exposure	50 V/m	20 V/m	1.0 mW/cm ²
Upper limit values of harmless radiation			
General population	480/t	240/t	0.24/t mW/cm ²
Occupational exposure	1200/t	480/t	2.4/t mW/cm ²
Forbidden areas: general population + occupational exposure	1000 V/m	500 V/m	10 mW/cm ²

Note: t = exposure time in hours (t > 1 hour).

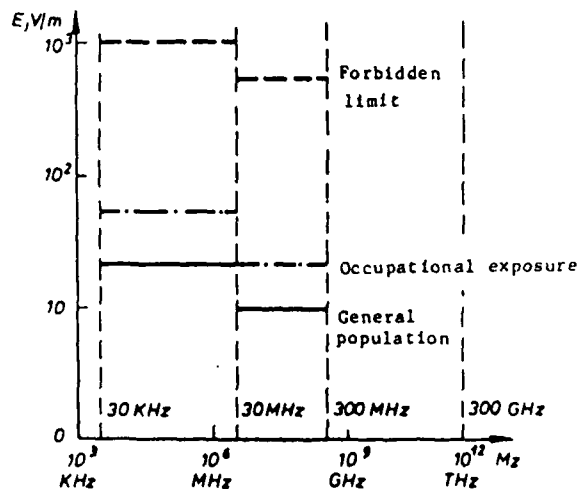


Figure 13.
Safe limits of electric field intensity for continuous exposure (Hungarian draft standard).

Current Research

Biological Effects of Nonionizing Electromagnetic Radiation VIII(1), October 1985

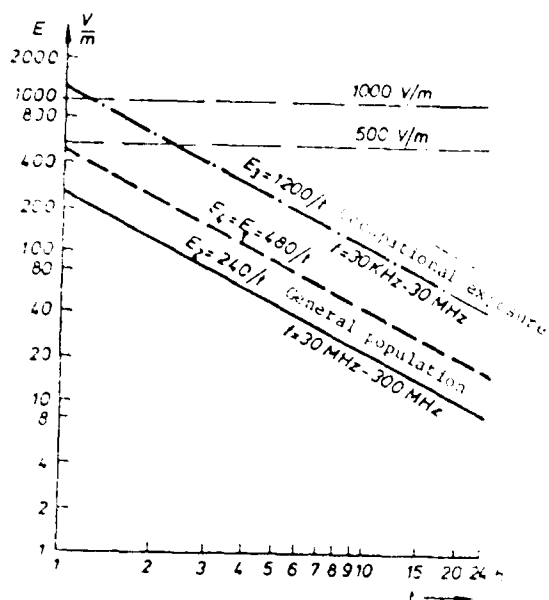


Figure 14.
Safe limits of electric field intensity for
intermittent exposure (Hungarian draft standard).

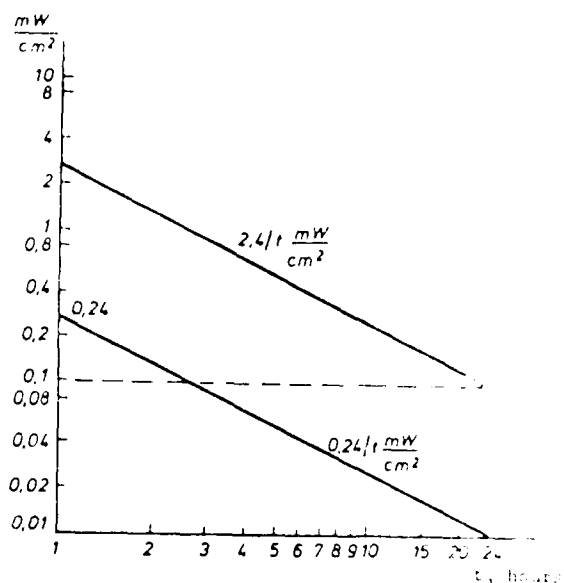


Figure 16.
Permissible values of microwave power density for
intermittent exposure (Hungarian draft standard).

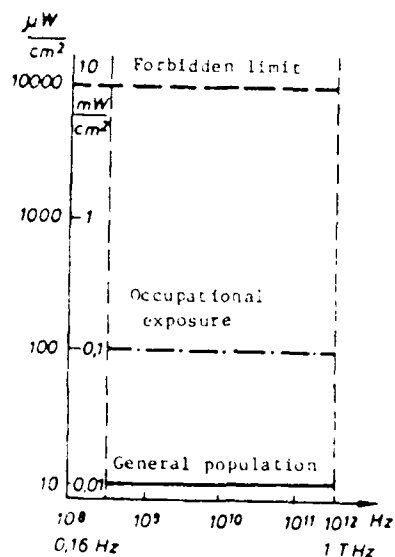


Figure 15.
Permissible values of microwave power density for
continuous exposure (Hungarian draft standard).

Table 11.

Standard	Scope	Frequency	Exposure limit	Exposure duration	Continuous/pulsed mode	Fixed/rotary antenna
Soviet standard 1974	Occupational Exposure	10-30 MHz	20 V/m	Work day	Both	Both
		30-50 MHz	10 V/m	Work day	Both	Both
			0.3 A/m	Work day	Both	Both
		50-300 MHz	5 V/m	Work day	Both	Both
		0.3-300 MHz	10 $\mu\text{W}/\text{cm}^2$	Work day	Both	Fixed
			100 $\mu\text{W}/\text{cm}^2$	Work day	Both	Rotary
			100 $\mu\text{W}/\text{cm}^2$	2 hours	Both	Fixed
			1 mW/cm^2	2 hours	Both	Rotary
			1 mW/cm^2	20 minutes	Both	Fixed
Soviet standard 1978	General Population	0.3-300 MHz	1 $\mu\text{W}/\text{cm}^2$	24 hours	Both	Both
Polish standard 1972	Occupational Exposure	0.3-300 MHz	0.2 mW/cm^2	10 hours	Both	Fixed
			0.2-10 mW/cm^2	32/P ² /hour/	Both	Fixed
			1 mW/cm^2	10 hours	Both	Rotary
			1-10 mW/cm^2	800/P ² /hour/	Both	Rotary
	General Population	0.3-300 MHz	10 $\mu\text{W}/\text{cm}^2$	24 hours	Both	Fixed
			0.1 mW/cm^2	24 hours	Both	Rotary
Polish recommended standard 1975	Occupational Exposure	10-300 MHz	20 V/m	Work day	Both	Both
			20-300 V/m	3200/E ² /hour	Both	Both
	General Population	10-300 MHz	7 V/m	24 hours	Both	Both
Czech standard 1970	Occupational Exposure	10-30 MHz	50 V/m	Work day	Both	Both
		30-300 MHz	10 V/m	Work day	Both	Both
			25 $\mu\text{W}/\text{cm}^2$	Work day	Continuous	Both
			10 $\mu\text{W}/\text{cm}^2$	Work day	Pulsed	Both
			1.6 mW/cm^2	1 hour	Continuous	Both
			0.64 mW/cm^2	1 hour	Pulsed	Both
	General Population	30-300 MHz	1 V/m	24 hours	Both	Both
		0.3-300 GHz	2.5 $\mu\text{W}/\text{cm}^2$	24 hours	Continuous	Both
			1 $\mu\text{W}/\text{cm}^2$	24 hours	Pulsed	Both
		30-300 MHz	1 V/m	24 hours	Both	Both
		10-30 MHz	2.5 V/m	24 hours	Both	Both

P = Power density W/m^2

E = Electric field density V/m

BIOLOGICAL EFFECTS OF NONIONIZING ELECTROMAGNETIC RADIATION DIGEST welcomes contributions from its readers. Information on meetings, news, current research and current literature is actively sought for publication in the DIGEST. Forms for submission of notices of current research projects are included at the back of this issue.

CURRENT LITERATURE

0655 TECHNIQUE FOR MICROWAVE-INDUCED HYPERTHERMIA IN SUPERFICIAL HUMAN TUMORS. (Eng.) Nilsson, P. (Dept. Radiation Physics, Univ. Hosp., S-22185 Lund, Sweden); Persson, B.; Kjellen, E.; Lindholm, C.-E.; Landberg, T. *Acta Radiol Oncol* 21(4):235-239; 1982 (16 refs).

A hyperthermia system consisting of a microcomputer-controlled 2450 MHz microwave (MW) generator is described. MW power is delivered via a circular direct contact applicator. Up to 8 thermistor probes connected to a temperature registration unit can be used simultaneously to measure tumor and skin surface temperature; digitized temperature signals are sent to the microcomputer for calculation of temperature and for control of the heating. One of the thermistors (usually the one inserted in the center of the tumor) is chosen as the master probe, and the temperature recorded at this probe is compared with a preset temperature value. Heating is started via a signal from the computer to the MW generator when temperature at the master thermistor is at least 0.2 C lower than the preset temperature. The power of the generator (maximum output power of 200 W) is selected manually to achieve a temperature increase of approximately 0.5 C during a 15-sec MW pulse. All probes are read 2 sec after MW energy is shut off by the computer, eliminating the problem of incorrect temperature measurement during MW irradiation due to interaction between the metallic wires of the probes and the electric field. When the preset temperature value is reached, the length of the pulse is adjusted by the control program so that temperature at the master thermistor does not fluctuate more than ± 0.5 C. This automatic control system has proven to be very reliable in clinical work.

0656 MICROWAVE-INDUCED HYPERTHERMIA AND IONIZING RADIATION. PRELIMINARY CLINICAL RESULTS. (Eng.) Lindholm, C.-E. (Dept. Oncology, Malmö Allmänna Sjukhus, S-21401 Malmö, Sweden); Kjellen, E.; Landberg, T.; Nilsson, P.; Persson, B. *Acta Radiol Oncol* 21(4):241-254; 1982 (70 refs).

Local hyperthermia induced by a computer controlled 2450 MHz microwave (MW) system was used alone or in combination with ionizing radiation to treat superficial tumors that were refractory to other therapy. Thermistor probes were placed within the tumor and on the skin surface; temperature of the probe designated as the master probe was maintained at 42.5 ± 0.5 C via the computer control system. The effects of hyperthermia alone, ionizing radiation alone (30 Gray in 10 fractions over 12 days), or hyperthermia (45 min 1/wk or 2/wk for 2 wk) with radiation were compared. Of 8 evaluable tumors given combined hyperthermia and radiation, 5 showed a complete and 3 showed a partial response while no response was seen in 3 tumors treated with ionizing radiation alone or in 1 tumor treated with heat alone. Combined therapy

was effective even in sites that had been irradiated previously. The MW applicator allowed heating of lesions less than 7 cm in diameter and 3 cm deep. The preset temperature at the master probe could be maintained at ± 0.5 C but differences of up to 3.5 C were observed between the different thermistors at a given treatment session. Side effects of hyperthermia included pain and skin burns.

0657 USE OF RADIO-FREQUENCY PULSED ENERGY IN THE CONTROL OF POSTOPERATIVE REACTION IN BLEPHAROPLASTY. (Eng.) Nicolle, F. V. (30 Harley St., London W1N 1AB, England); Bentall, R. M. *Aesthetic Plast Surg* 6(3):169-171; 1982 (9 refs).

Clinical results obtained with a portable device used to apply small pulses of radiofrequency (RF) energy to surgical wounds are reported. The device consists of a small oscillator tuned to 27.12 MHz with a timer switching the oscillator so that small pulses of RF energy (square, 100- μ sec long pulses; 1000 pulses/sec) are emitted from the single turn coaxial coil. The unit is powered by a small nickel-cadmium battery that can be used for 5 days without recharging. The area of the coil is approximately 6 cm in diameter. In order to adapt the device to fit over the eyelid region, two wire loops were designed in the shape of an eyeglasses frame and held in place with light padding and a bandage. Only one loop was electrically active; the other provided a control. The device was applied for 24 hr to one eye in 21 consecutive patients after bilateral blepharoplasty. No device-related complications were observed. Improvement was apparent in 11/13 cases where sufficient ecchymosis and edema existed for comparison; ecchymosis and swelling were so slight in 6 cases that no difference was visible between treated and untreated sides. Two cases were judged to be worse on the treated side and 2 were excluded because of displacement of the dressings by the patients. A similar device with larger loops to cover the neck and sides of the face is being used in face and neck lifts.

0658 REACTION OF NORMAL EQUINE EYES TO RADIO-FREQUENCY CURRENT-INDUCED HYPERTHERMIA. (Eng.) Neumann, S. M. (Dept. Clinical Sciences, Coll. Veterinary Medicine and Biomedical Sciences, Colorado State Univ., Fort Collins, CO 80523); Kainer, R. A.; Severin, G. A. *Am J Vet Res* 43(11):1938-1944; 1982 (4 refs).

The long-term effects of treatment of equine ocular tumors with radiofrequency (RF) current-induced hyperthermia were studied. The eyes of 13 horses and 8 ponies were subjected to a 30-sec application of RF current (2 MHz, 7 or 10 W); the eyes of 3 horses were sham-treated. The electrodes of a localized

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current field device were applied horizontally to the central cornea in the right eye and horizontally and vertically to 2 separate limbal sites in the left eye. Mean temperatures at the 2 corneal sites was 48.7°C; at the 4 limbal sites, 56.0°C. In eyes observed from 1 to 6 mo after treatment, scars persisted at 1 central corneal site (4.5%) and 6 limbal sites (27.3%) where electrodes were positioned vertically. Pathologic changes observed up to 1 wk after treatment included transient ulcerative keratitis and anterior uveitis. Vision was not compromised in any of the animals permitted to live beyond 1 wk.

0659 ACCELERATION OF THE DEVELOPMENT OF BENZOPYRENE-INDUCED SKIN CANCER IN MICE BY MICROWAVE RADIATION. (Eng.) Szudziński, A. (Dept. Dermatology, Postgraduate Centre, Military Medical Acad., Szaserów 128, PL-00-909 Warsaw, Poland); Pietraszek, A.; Janiak, M.; Wrembel, J.; Kalczak, M.; Szmiłgielski, S. Arch Derm Res 274(3-4):303-312; 1982 (20 refs).

The possible co-carcinogenic activity of long-term low-level microwave (MW) radiation was studied in Balb/c mice. Skin cancer was induced in the mice by chronic exposure to 3,4-benzopyrene painted on the dorsal skin every 2 days for up to 6 mo. Mice were exposed to 2450 MHz MW energy (from a Lucz 58 generator with maximum output power of 150 W) in a temperature and humidity controlled anechoic chamber at incident power levels of 5, 10, or 15 mW/cm² (specific absorption rates of 2, 4, and 6 mW/g, respectively) for 2 hr/day, 6 days/wk, for up to 6 mo. Mice were divided into six experimental groups of 100 animals each. Mice in groups 1 and 2 were simultaneously exposed to benzopyrene treatment and MW energy (5 mW/cm² or 15 mW/cm²) for 6 mo. Mice in groups 3-5 were irradiated for 1, 2, or 3 mo before the beginning of benzopyrene treatment. Control animals were exposed to benzopyrene treatment for 6 mo and sham-irradiated for 2 hr/day for 1, 2, 3 or 6 mo. All MW irradiation protocols resulted in significant stimulation of the development of benzopyrene-induced skin cancer and in shortening of the life span of the tumor bearing hosts. The effect was more pronounced both after exposure to higher power densities and after longer exposure periods. When benzopyrene treatment was preceded by or concomitant with MW irradiation, skin reactivity to dinitrofluorobenzene was markedly inhibited, suggesting that long-term exposure to low-dose 2450 MHz MW radiation may suppress cellular immune reactions.

0660 INTERRELATIONSHIPS BETWEEN WATER AND CELL METABOLISM IN ARTEMIA CYSTS. X. MICROWAVE DIELECTRIC STUDIES. (Eng.) Clegg, J. S. (Lab. Quantitative Biology, Univ. Miami, Coral Gables, FL 33124); Szwarzowski, S.; McGlean, V. E. R.; Shep-

pard, R. J.; Grant, E. H. Biochim Biophys Acta 641:458-468; 1982 (50 refs).

The dielectric properties of cysts of *Artemia*, a primitive crustacean known as the brine shrimp, were measured over the frequency range 1.5-70 GHz. *Artemia* cysts are composed of about 4000 closely-packed cells surrounded by an acellular shell and can undergo cycles of hydration-dehydration without loss of viability. Measurements were performed on cysts with various water contents, primarily 1 g H₂O to 1 g dried cysts. Complex permittivity measurements were made at 0.8, 2, and 4 GHz with a coaxial line apparatus; those at 15, 35, and 70 GHz were made with a waveguide apparatus. At each frequency except 70 GHz, the permittivity showed an increase as the water content of the cyst was increased. At the high hydration values, the permittivity leveled off. At 70 GHz, permittivity was linearly dependent on cyst water content. The permittivity of the intracellular water at 35 GHz was estimated as 16 which is 30% below that for pure water at 34 GHz. The authors assumed that water exists as bulk and non-bulk fractions in the cysts and calculated that 43% of the cellular water had a permittivity equal to that of pure water.

0661 MICROWAVE MODULATION OF NEURAL ACTIVITY. (Eng.) Wachtel, H. (Dept. Electrical Engineering, Univ. Colorado, Boulder, CO). Biomed Sci Instrum 18:45-50, 1982 (6 refs).

A mathematical model is presented which can be used to predict optimal microwave (MW) pulse parameters for perturbing neural activity with minimal risk of damage due to temperature rise or excessive current density. The model, which is based on the observation that low levels of MW power can rapidly produce changes in the firing patterns of isolated *Aplysia* pacemaker neurons and that MW pulses may be equivalent to injected transmembrane DC pulses, suggests that a distinct minimum pulse energy exists when pulse duration (in sec) equals 1.2 x the membrane time constant. Noninvasive modulation of neuronal activity by MW pulses could have numerous biomedical applications.

0662 MICROWAVE ABSORPTION OF DNA BETWEEN 8 AND 12 GHz. (Eng.) Swicord, M. L. (Bureau of Radiological Health, 12721 Twinbrook Parkway, Rockville, MD 20857); Davis, C. C. Biopolymers 21(12):2453-2460; 1982 (11 refs).

The microwave (MW) absorption coefficients of aqueous solutions of DNA extracted from *Escherichia coli* 11 were measured over the frequency range 8-12 GHz. The phase fluctuation optical heterodyne technique

was used to monitor the temperature rise induced in a sample by pulsed MW irradiation. In this technique, a single frequency He-Ne laser beam traverses the sample while the sample is heated with 10 mJ pulses of MW energy. The heating of the liquid sample when it absorbs MW energy induces a phase chirp in the laser beam. The absorption coefficient of the sample is determined from a plot of optical heterodyne signal as a function of the distance of the laser beam from the surface of the liquid. The maximum random error in the system was less than 2% as determined from measurements on deionized water and other media such as saline solutions and methanol. The attenuation coefficient of the DNA solution was greater than that of water and saline solution. The absorption coefficient of the DNA solution was 40% higher than water at 8 GHz, decreasing to 10% higher at 12 GHz. At 6 GHz, the absorption coefficient of the sample, which had a measured dc conductance of 0.67 mmhos/cm, was 25% higher than that of a saline solution of 20 times greater dc conductance. Thus, the absorption in the DNA solution does not arise from ionic behavior but is in agreement with absorption by the longitudinal acoustic mode of the double helix.

0663 FALSE CLAIMS FOR MAGNETOTHERAPY (LETTER TO EDITOR). (Eng.) Orpin, J. A. (Bureau Medical Devices, Health Protection Branch, Dept. National Health and Welfare, Ottawa, Ont., Canada). Can Med Assoc J 126(12):1375; 1982 (no refs).

In response to many requests from physicians regarding medical applications of magnetic fields, the author states that there is no scientific evidence of any usefulness of magnetotherapy. The units used for this therapy consist of a coil through which direct current passes and may be pulsed 1 to 50 times per sec. The magnetic field, which can reach a value of 10 mT, approximates that found near a small 100-W transformer. He further states that findings in the literature concerning magnetotherapy often conflict and that no properly controlled trial has been conducted.

0664 CLAIMS FOR MAGNETOTHERAPY (TWO LETTERS TO EDITOR). (Eng.) Bassett, C. A. L. (Orthopaedic Res. Labs., Coll. Physicians and Surgeons, Columbia Univ., New York, NY); Orpin, J. A. Can Med Assoc J 127(11):1079-1080; 1982 (no refs).

Regarding Orpin's letter to the editor in Can Med Assoc J 126:1375, 1982 [see Abstract No. 0663], it is necessary to differentiate between electromagnetic devices for which unfounded claims have been made and those which have been thoroughly investigated in controlled laboratory and clinical conditions such as the use of highly specific pulsed electromagnetic

as the use of highly specific pulsed electromagnetic fields in fractures that fail to heal, failed arthrodeses and congenital pseudarthroses. Orpin responds that his letter referred to magnetic equipment currently advertised in Canada and not to devices used in research that are not yet available for clinical use. A more precise terminology and a classification system for devices that deliver diagnostic or therapeutic energy based on their levels of acceptance and authenticity are proposed.

0665 NEUROPHYSIOLOGICAL EFFECTS OF ELECTROMAGNETIC FIELDS. A CRITICAL REVIEW. (Eng.) Hansson Mild, K. (National Board Occupational Safety and Health, Dept. Occupational Health, Box 6104, S-900 06 Umea, Sweden); Oberg, P. A. Electroencephalogr Clin Neurophysiol [Suppl] 36:715-729; 1982 (58 refs).

The neurophysiological effects produced by exposure to 0-300 GHz electromagnetic (EM) fields at levels considered to be non-thermal are reviewed. Occupational exposure to near- and far-field radiation is discussed. The effects of constant and alternating magnetic fields at the cellular level of the nervous system have been studied in giant axons of lobsters, frog nerve-muscle preparations, frog retina and sciatic nerves, cat saphenous nerves, rabbit vagus nerves and superior cervical ganglia, and the abdominal ganglia of *Aplysia californica*. At the organ level, calcium fluxes in cat and chick brain tissue exposed to modulated EM fields and heart rate changes in isolated perfused rat hearts exposed to microwave (MW) irradiation have been reported. The results of studies of EM field effects on different mammals are reviewed. Effects observed in humans exposed to EM fields include deep heating in tissue during shortwave and MW diathermy, a faint flickering visual sensation when the head is exposed to electric currents or magnetic fields, and auditory perceptions when the head is exposed to pulse-modulated MW energy above a certain intensity level. The neurasthenic syndrome (headache, irritability, dizziness, loss of appetite, sleeplessness, sweating, difficulties in concentration or memory, depression, emotional instability, dermatographism, thyroid gland enlargement, and tremor of extended fingers) has been reported in epidemiological studies of workers exposed to radiofrequency (RF) and MW radiation. There appears to be a general consensus that the majority of biological effects of RF and MW fields can be explained by thermal energy conversion. For frequencies in the kHz range the possibility exists of direct nerve excitation by induced eddy currents at very high magnetic field strengths. Modulated fields appear to have a greater ability for interfering with biological material than do continuous waves. Both amplitude modulated ultra high frequency fields and extremely low frequency fields with frequencies in the range 6-30 Hz have been shown to affect brain tissue and bioelectrical activity. However, the level of

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knowledge of the mechanisms behind EM field effects on biological systems is still low.

0666 RADIOFREQUENCY AND MICROWAVE RADIATION. (Eng.) Hileman, B. (No affiliation given). Environ Sci Technol 16(8):442A-444A; 1982 (no refs).

The environmental effects of radiofrequency and microwave radiation are reviewed. Results of animal studies are outlined briefly. Standards and guidelines for exposure to microwave radiation vary by 3 orders of magnitude (up to 100, 1000, or 10,000 $\mu\text{W}/\text{cm}^2$). The U.S. has no federal standards adopted by the government through the regulatory process for the protection of workers or the general population from either microwave or radiofrequency radiation.

0667 AN INCREASE IN COLONY-FORMING CAPACITY OF THE BONE MARROW STEM CELLS AFTER MICROWAVE IRRADIATION IN VITRO. (Eng.) Rotkowska, D. (Inst. Biophysics, Czechoslovak Acad. Sciences, 612 65 Brno, Czechoslovakia); Vacek, A. Folia Biol (Praha) 28(2): 138-141; 1982 (7 refs).

The effect of microwave (MW) radiation on bone marrow cell suspensions in vitro was investigated in mice. Bone marrow cell suspensions in Hanks' solution were irradiated for 5 min (2450 MHz, 65 mW/cm^2 , temperature increase of 6 C) and injected iv into x-irradiated isogenic recipients 10, 30, or 45 min after MW exposure. On day 10 after transplantation, a significant increase in the number of colony forming units was observed for the bone marrow cell suspension transplanted within 10 min of MW exposure but no difference was observed for the suspension transplanted 45 min after MW irradiation. In a control experiment, the colony forming capacity of bone marrow heated in a water bath was not affected by a rise in temperature comparable to that reached during MW irradiation. The repopulation activity of bone marrow cells added to MW-irradiated Hank's solution and transplanted after 20 min incubation at room temperature was almost equal to that of MW-irradiated bone marrow suspensions. The results suggest that the effect of MW radiation on the colony forming capacity of the bone marrow may be indirect and may be mediated by alterations in the MW-irradiated solution.

0668 CHANGES IN CARDIAC-CELL MEMBRANE NOISE DURING MICROWAVE EXPOSURE. (Eng.) Seaver, R. K.; DeHaan, R. L. (Biomedical Res. Div., Georgia Tech Engineering Experiment Station, Atlanta, GA 30332); Seaver, R. K.; DeHaan, R. L. 1982 IEEE MTT-S Digest:

436-438; 1982 (11 refs).

The membrane voltage noise of cardiac-cell aggregates was studied during microwave (MW) irradiation as a probe of the molecular mechanism of interaction between electromagnetic (EM) energy and an excited cell membrane. Aggregates of embryonic white leghorn chicken heart cells in culture were placed in an open-ended coaxial exposure device connected to a source of continuous wave, 2450 MHz MW energy. The temperature of the medium was maintained at $37 \pm 0.1^\circ\text{C}$. During irradiation at specific absorption rates of 122 to 237 mW/g , the local temperature of the aggregates increased by no more than 0.8 C. Membrane voltage noise was recorded from 5 different aggregates in a total of 8 exposures. Average pre-exposure value of power for the 8 exposures was -83.0 ± 3.12 dB; during the beginning of exposure, it was -82.36 ± 4.25 dB. Average powers for the first 5 exposures were -83.39 ± 3.87 dB and -81.44 ± 2.1 dB for pre-exposure and beginning epochs, respectively. The average increase in power during the beginning of exposure was 0.99 ± 3.93 dB over the 8 exposures and 1.94 ± 3.81 dB for the first 5 exposures. Because of the large variability, this result is inconclusive and further experiments are in progress.

0669 A SELF-BALANCING MICROWAVE RADIOMETER FOR NON-INVASIVELY MEASURING THE TEMPERATURE OF SUBCUTANEOUS TISSUES DURING LOCALIZED HYPERTHERMIA TREATMENTS OF CANCER. (Eng.) Sterzer, F. (AT&T Labs., Princeton, NJ 08540); Paglione, R.; Wornat, F.; Mendecki, J.; Friedenthal, E.; Botstein, L. 1982 IEEE MTT-S Digest:438-440; 1982 (6 refs).

The use of a self-balancing radiometer operating at 2350 to 2550 MHz to non-invasively measure subcutaneous tissue temperature during localized radiofrequency (RF, 27 MHz) and microwave (MW: 2450 MHz) hyperthermia treatments for cancer is described. While 2450 MHz contact applicators are used for treating cutaneous and subcutaneous tumors, the applicator serves as the antenna of the radiometer and receives the thermal radiation from the heated tissues. While 27 MHz applicators are used to heat deep-seated tumors, tissue temperatures are measured by removing the applicator after heating and then measuring the thermal noise power emitted by the heated tissues. A ceramic filled waveguide applicator usually serves as the antenna of the radiometer. Current limitations of radiometers of this type are that only average rather than point temperatures are measured by this method, and the depths at which tissue temperatures are measured are relatively shallow.

0670 THERMAL DRIFT IN MICROWAVE THERMOGRAPHY. (Eng.) Shaeffer, J. (Dept. Radiat. Phys.,

Oncology and Biophysics, Eastern Virginia Medical Sch., Norfolk, VA 23507); El-Mahdi, A. M.; Bielawa, R.; Regan, J. F.; Carr, K. L. 1982 IEEE MTT-S Digest:441-443; 1982 (3 refs).

During microwave (MW) thermography for the measurement of subcutaneous tissue temperature, prolonged contact between the MW antenna at one temperature and a subject at a different temperature results in thermal drift, the apparent change in the subject's temperature. Thermal drift may be positive or negative depending on the nature of the thermal mismatch between antenna and subject. It can be eliminated or minimized by appropriate thermal matching of subject and antenna and improvement in antenna design.

0671 DYNAMIC IN VIVO PERFORMANCE OF TEMPERATURE CONTROLLED LOCAL MICROWAVE HYPERTHERMIA AT 2.45 GHz. (Eng.) Knochel, R. (Philips Res. Lab., Vogt-Kolln-Strasse 30, D-2000 Hamburg, W. Germany); Meyer, W.; Zywiets, F. 1982 IEEE MTT-S Digest:444-447; 1982 (4 refs).

A temperature-controlled 2.45 GHz microwave (MW) system for local heating of small animal tumors is described which consists of a Philips MW 127 generator (25 or 200 W maximum output power) operating in a pulsed power mode, micro-thermocouple temperature monitoring equipment and three different applicators: commercially available non-contact spiral antenna, ceramic-filled waveguide and cross-fire arrangement of two ceramic-filled antennas in cophase. It was capable of inducing an intratumor temperature of 43°C within 3 min and maintaining it within ± 0.1 °C during 15-min treatment sessions. Comparison of the control-loop response in phantom tissue and in solid tumors (rhabdomyosarcoma R1H) in anesthetized rats showed significantly different heat distributions during both transient and stationary phases of heat control. Interference between thermocouples and electromagnetic fields was reduced by orthogonal positioning of the thermocouples and by at least a 1 sec interval between turning off MW power and temperature sampling. The ceramic-filled waveguide antennas exhibited better coupling between the tumor and the antenna than the spiral antenna. Although positioning of the rat was not as easy as with a single applicator, the crossfire arrangement of applicators was the most efficient: less power per applicator was applied and faster heating to the final temperature was obtained.

0672 BIOLOGICAL EFFECTS AND MEDICAL APPLICATIONS OF RF ELECTROMAGNETIC FIELDS. (Eng.) Gandhi, O. P. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112). IEEE Trans Microwave Theor Tech 30(11):1831-1847; 1982 (113 refs).

Current knowledge about the biological and medical effects of exposure to radiofrequency electromagnetic fields is summarized. Ocular, thermal, and behavioral effects, enhanced efflux of ions from chick and cat cortex tissues, and synergistic effects between microwave radiation and chemotherapeutic drugs have been reported. A few studies with exposures lasting up to 16 wk have been conducted. Results of the first 15 mo of a program of simulating human exposure to the Air Force AFOSR system are discussed. Factors affecting whole-body absorption of electromagnetic radiation are summarized. A lower, frequency-dependent safety standard has been recommended by the ANSI C95 committee. The allowed power densities are calculated to estimate whole-body averaged specific absorption rates less than or equal to 0.42 W/kg over the frequency range 3-100,000 MHz. Medical applications of electromagnetic fields include hyperthermia as an adjunct to cancer therapy, biomedical imaging, and radiofrequency wave heating of the animal head as a technique for sacrificing animals and inactivating brain tissue. Areas that need further investigation are discussed.

0673 UN-UNITED FRACTURES. PART I: THE USE OF ELECTROMAGNETIC FIELDS: A NON-TRAUMATIC WAY TO PRODUCE BONY UNION. (Eng.) Brighton, C. T. L. (Dept. Orthopaedic Surgery, Columbia University, Physicians & Surgeons, 630 W. 168 St., New York, NY 10032). Instr Course Lect 31:88-94; 1982 (36 refs).

The first article of a three-part series on un-united fractures describes the use of pulsed electromagnetic fields (PEMFs) to stimulate the healing of un-united fractures. A study of 1078 un-united fractures in patients with un-united fractures or failed attempts at bony union treated with PEMFs revealed a success rate of 77% for the first attempt to produce union by this method [see Abstract No. 0068]. A success rate of 92% was seen in a series of 53 un-united fractures of the tibial diaphysis treated at Columbia University Medical Center in 1979. Contraindications to the method and procedures that are important to the success are outlined. PEMFs and bone healing appear to work synergistically to assure union. PEMFs are used in clinical evaluations to treat vascular necrosis, loosened prostheses, delayed union, osteoporosis, and Paget's disease, and, in the laboratory, they have proved effective in the repair of peripheral nerve lesions.

0674 UN-UNITED FRACTURES. PART II: THE USE OF CONSTANT DIRECT CURRENT IN THE TREATMENT OF NONUNION. (Eng.) Brighton, C. T. L. (Dept. Orthopaedic Surgery, Sch. Medicine, Univ. Pennsylvania, Philadelphia, PA 19104). Instr Course Lect 31:95-103; 1982 (36 refs).

cases of damage to the environment in oil spills and the damage should be attributed to the negligent technique, instead of to the use of existing technology. The authors

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0679 EFFECTS OF FREQUENCY AND POWER ON SKIN RESPONSES OF RADIATION-SENSITIVE MONKEYS EXPOSED TO MICROWAVES. (Eng.) W. L. H. (Naval Air Station Medical Res., Orlando, FL 32816); S. J. G. (Naval Air Station, Orlando, FL 32816); R. P. (Naval Air Station, Orlando, FL 32816). 1982 (2 refs).

Whole-body and partial-body thermal response to microwave exposure was similar in rhesus monkeys to that observed in other primate species. Rectal temperature, skin surface levels of cortisol, thyroxine (T_4), and 2,4-dihydroxy-6-methylphenol (DHP) were measured in rhesus monkeys exposed to pulsed MW power (1.29 GHz; pulse width 100 μ sec; pulse repetition rate, 337/sec) produced by a military type AN/TPS-1G radar. Whole-body thermal responses of the chair-restrained monkeys were similar to those reported in other primate conditions. In partial-body exposures at 1, 27, 28, and 38 mW/cm² (100 μ sec pulse width), corresponding specific absorption rates (SAR) were 0.001, 0.01, 0.02, and 0.04 W/kg. Blood samples were collected from the jugular vein (dorsal jugular veins) at 15 min before, during, and after the MW exposure. Rectal temperature (average of 10, 15, and 17 C) decreased slightly for the three intensities used, whereas 10% or 0% were observed. Only the 38 mW/cm² exposure resulted in marked increases in cortisol and T_4 . The results indicate that whole-body thermal response was very low to 1.29 GHz pulsed MW. A threshold intensity of exposure (between 28 and 38 mW/cm²) was concluded for rectal temperature and adrenocortical responses to MW exposure in the rhesus monkey are comparable to those reported in other animal models.

0680 NEUROLOGICAL EFFECTS OF REPAIR WITH SEVERAL TYPES OF ANISOTROPIC ELECTROMAGNETIC FIELDS. (Eng.) J. A. T. (Philadelphia Fed. Lab., Univ. of Pennsylvania, Philadelphia, PA 19104); J. A. T. (New York, NY 10033); V. J. (New York, NY 10033); V. J. (New York, NY 10033). 1982 (5 refs).

The effects of repeated exposure to electromagnetic fields (EMF) on the neurological and histological responses of rats to one of the radio frequencies (RF) were studied in Lewis rats. The rats were divided into three groups: control, RF, and RF + repair. The RF group was exposed to a 100 MHz, 100 W, 100 μ sec pulse width, 100 μ sec pulse repetition rate for 2 wk. The RF + repair group was exposed to the same RF for 2 wk, followed by a 100 MHz, 100 W, 100 μ sec pulse width, 100 μ sec pulse repetition rate for 2 wk. The rats were sacrificed on Day 14. The brains were sectioned and stained. The results showed that the RF group had a significant increase in the number of neurons in the hippocampus and the cerebellum. The RF + repair group had a significant increase in the number of neurons in the hippocampus and the cerebellum. The results indicate that repeated exposure to RF can cause neurological damage in rats, and that repair with RF can reduce this damage.

Other tests included examination of venular morphological features and measurement of fibrocartilage and fibrous-tissue width at the level of the osteotomy and diameter of the callus. Animals exposed to a 5 msec, 5 Hz pulse produced a 1-sec mean load value that was 1.45-fold greater than the control value and a 30-sec value that was 1.13-fold greater; total load decay was 15% less. Histological data were compatible with the load data. The results suggest that total energy is not a major factor in pulse effectiveness and that specific waveform characteristics may be required to trigger selective biological responses.

0681 STUDIES OF LONG-TERM EXPOSURE OF THE PORCINE BRAIN TO RADIATION FROM TWO-WAY PORTABLE RADIOS (MEETING PAPER). (Eng.) Sutton, C. H. (Div. Neurosurgery, Univ. South Florida Coll. Medicine, Tampa, FL 33612); Balzano, Q.; Garay, O.; Carroll, F. R. J. Microwave Power 17(4):280-281; 1982 (2 refs).

To assess the effect of prolonged exposure to intermittent microwave (MW) energy on the brain, 15 200-lb pigs were fitted with a leather harness holding a standard two-way portable radio (Motorola, Model MX350, 452 MHz, 6.4 W) so that the antenna remained at a distance of 1.5 cm from the frontal midline of the scalp. After a 1-mo training period to habituate the pigs to the headgear, 8/15 pigs were irradiated for 8 hr/day for 90 days. To simulate intensive use of a radio by a human operator, MW exposure was composed of repeated 10-min cycles (1 min continuous-wave radiation, 9 min pause). After 90 days, all animals were sacrificed. Each animal was injected with Evans Blue 1 hr prior to sacrifice. No areas of blood brain barrier disruption were encountered and there was no evidence of brain edema. In addition to routine processing of brain tissue for hematoxylin and eosin stains, neurohistological special stains were prepared and several enzyme histochemical incubations were carried out. There was no evidence of injury to brain tissue in either the 8 irradiated pigs or the 7 nonirradiated pigs. The results indicate that repeated daily exposure to 452 MHz MW energy does not produce detectable brain injury in pigs and that it is unlikely that similar usage of two-way portable radios in humans will produce any brain injury or blood-brain barrier disruption.

0682 SYNERGISTIC EFFECTS OF MICROWAVES AND PENTOBARBITAL IN LABORATORY RATS (MEETING PAPER). (Eng.) De Witt, J. R. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); D'Andrea, J. A. J. Microwave Power 17(4):282-283; 1982 (5 refs).

The effects of combined doses of pulsed microwave (MW) radiation and sodium pentobarbital on the acquisition of shuttle-box avoidance responses were studied in 24 male Long-Evans rats. Six groups of rats were given different combinations of sodium pentobarbital (0, 10, or 15 mg/kg, ip) followed by MW radiation (0 or 1 mW/cm², 3-GHz carrier wave, 500 pulses/sec, 2- μ sec pulse width, for 30 min). After either sham radiation, rats were removed to a shuttle box and given 10 min to explore and adapt before training was begun. The conditioning stimulus (CS) was a combination of sound from a speaker (80 dB) and illumination from the 24-V lamp in the chamber that the rat happened to occupy at the onset of the CS. During the training trials, the CS preceded the unconditioned stimulus (US: 0.73 mA scrambled shock of constant current delivered to the grid floor of the shuttle-box) by 10 sec and stayed on until the rat made an avoidance, escaped from the shock, or 120 sec of footshock had been given. A training session consisted of 50 trials with an average 30-sec intertrial interval. The effect of drug dose and the interaction between drug dose and radiation treatment were statistically significant. Increases in drug dose were associated with decreased latencies to escape or avoid for both radiated and nonradiated rats. There was no difference between radiated and nonradiated rats receiving 15 mg/kg. However, radiated rats given either 10 or 15 mg/kg were slower than nonradiated rats given the same dose suggesting that there was a synergism between pulsed MW radiation and drug doses of 10 and 15 mg/kg pentobarbital.

0683 RF HYPERTHERMIA APPLICATOR WITH MOVING ELECTRODES (MEETING PAPER). (Eng.) Curran, T. C. (Dept. Electrical Engineering, Univ. of Alberta, Edmonton, Alberta, Canada T6G 2G7); Voss, W. A. G. *J. Microwave Power* 17(4):284-285; 1982 (2 refs.).

Small agar phantoms and capacitive electrodes mounted through an 80 degree arc were submerged and heated in a saline water bath to 22.1 C. Small capacitive electrodes provided 200 W at a frequency of 1.75 MHz for 10 min. Temperature gradients in the agar cylinder are illustrated. Extrapolation of the data suggests that this technique could be used to achieve a tumor temperature of 45-50 C while maintaining all other body temperatures normal.

0684 A SIMPLE PRECISE METHOD TO MEASURE PD AND LOSS TANGENT FOR BIOLOGICAL SAMPLES (MEETING PAPER). (Eng.) Shen, Z.-Y. (Microwave Res. Inst., Inst. of Phys., Acad. Sinica, New York, 333 Jay St., Brooklyn, New York, U.S.A.). *J. Microwave Power* 17(4):287-289; 1982 (2 refs.).

The transmitted power method to measure the power density (PD) on the surface of biological samples is presented. The method has been applied to a liquid sample in a quarter-wave resonator. The power behind a sample, which is proportional to the PD at the front of the sample, is proportional to the PD at the back of the sample. To determine the proportionality constant, a small sample is placed in a TE₁₀ waveguide. The cross section of the sample is made the same as the cross section of the waveguide. The PD of the sample is used to measure the PD of the waveguide. The PD is determined by measuring the transmitted power with the same small sample in the waveguide, keeping the surface of the sample perpendicular to the incident wave. In a biological sample, the incident power and reflected power are measured at the input waveguide of a horn antenna. The method gives the value of the SAR, dielectric constant, electrical conductivity, dielectric loss tangent of the sample.

0683 EFFECT OF LOW LEVEL MICROWAVE RADIATION ON THE DUODENAL ACTION POTENTIALS OF ANESTHETIZED RAT. (Eng.) Habash, R. W. Y. (Dept. Biology, Coll. Science, Univ. of Illinois, Urbana, Illinois, U.S.A.). *J. Microwave Power* 17(4):329-333; 1982 (3 refs.).

Chromium-nickel insulated electrodes were inserted in the duodenal wall of 7 male wistar rats. The effects of 2.45 GHz microwave (MW) radiation on the smooth muscle. Rats in individual plastic cages were irradiated in a multimode cavity at 5, 7.5, or 10 mW/cm² for 1-4 hr. Specific absorption rates measured by readings of forward and reflected power at 5, 7.5, and 10 mW/cm² were 5.35, 7.5, and 10 mW/g, respectively. During irradiation, the slow-wave frequencies accelerated 1-2% at 5 mW/cm² MW exposure began (by 9% at 5 mW/cm² in 90% of the cases and by 19% at 7.5 mW/cm² in 90% of the cases) and disappeared 10-15 min after termination of exposure. Duodenal action potentials were affected by radiation; the effect was more marked at 7.5 mW/cm² than at 5 mW/cm². The results show that duodenal electrical activity is affected by MW radiation. The accelerating effect on duodenal electrical activity is dependent on thermal activity while the effect on action potentials is dependent on non-thermal MW effect.

0684 LACK OF MUTAGENIC EFFECT OF 2.45-GHz MICROWAVE RADIATION ON *ASPERGILLUS NIDULANS* GROWN IN 8.7175-GHz CW MICROWAVES. (Eng.) Habash, R. W. Y.; Al-Harithi, H. T. (Dept. Biology, Coll. Science, Univ. of Illinois, Urbana, Illinois, U.S.A.). *J. Microwave Power* 17(4):345-351; 1982 (3 refs.).

The mutagenic effects of 8.7175 GHz continuous wave (CW) microwave (MW) radiation were studied in conidia of *Aspergillus amstelodami*. Conidia were exposed in the near field of a horn antenna for 3 or 6 hr at an estimated incident power density of 2.09 mW/cm². Exposures were carried out in the dark at temperatures ranging between 28 and 30 C. During irradiation, the suspension was continuously stirred by a rotating magnetic stirrer (rate of rotation, 14 Hz; a 16.87×10^{-3} tesla magnetic field was induced by the stirring device). The frequencies of conidial color variants and of 8-azaguanine resistant mutants in treated and untreated populations were compared. Both treated and untreated conidial populations gave similar frequencies in morphological and in drug-resistant mutants. The response was not affected by exposure duration or by temperature elevation (2.2 C and 2.4 C higher than controls after 3- and 6-hr exposures, respectively). The results demonstrate a lack of genetic response of conidia of *A. amstelodami* to 8.7175 GHz CW MW radiation.

- 0685 PSYCHOLOGICAL SYMPTOMS AND INTERMITTENT HYPERTENSION FOLLOWING ACUTE MICROWAVE EXPOSURE. (Eng.) Forman, S. A. (Navy Environmental Health Center, Norfolk, VA 23511); Holmes, C. K.; McManamon, T. V.; Wedding, W. R. *J Occup Med* 24 (11):932-934 (11 refs).

Psychological symptoms and hypertension following accidental, acute, high-level exposure to X-band microwave (MW) radiation are reported in two healthy men operating a portable high-power MW radar tracking system during military field maneuvers. The exposures occurred in the radiating near field and were from a continuous wave beam from a uniformly illuminated circular aperture antenna. The worst case, a 54 yr old man who was exposed continuously for 80 sec, showed an electric field strength of 475-580 V/m (corresponding to an equivalent plane wave power density of 60-90 mW/cm²). Immediate effects were severe chest pain, vertigo, and a heating sensation of the chest and head. Rapid onset of recurrent, severe headaches, insomnia, irritability, and emotional lability were also experienced. Peak severity of the subjective complaints occurred 3 mo after the exposure, coincident with a diagnosis of arterial hypertension in the range of 160/105 which was controlled with medication. After 1 yr of follow-up, blood pressure readings were normal but psychological problems of varying severity persisted. A 21-yr-old man sustained intermittent exposure to the MW beam over a period of 5 min (total time of irradiation, approx. 75 sec). Immediate effects included a heating sensation of the head and chest and a headache. Irritability, insomnia, headaches, photophobia, and visual blurring were experienced subsequently. Hypertension of 140/105 was detected 4 mo after the incident; it was controlled with medication. Blood pressure was normal at the 12-mo follow-up; emotional lability and insomnia persisted. No organic basis was discovered for the psychologi-

cal problems or the hypertension experienced by the men; a diagnosis of acute post-traumatic stress disorder was given in both cases. Two other healthy men, aged 30 and 39 yr, were exposed to the same power density for 5-10 sec. They reported vertigo, and a heating sensation, but these symptoms did not persist beyond 3 wk after the exposure.

- 0686 DEVELOPMENT AND USE OF A NONRESTRAINING WAVEGUIDE CHAMBER FOR RAPID MICROWAVE RADIATION KILLING OF THE MOUSE AND NEONATE RATS. (Eng.) Schneider, D. R. (Dept. Pharmacology, School of Medicine, Wayne State Univ., 540 East Canfield, Detroit, MI 48201); Felt, B. T.; Rappaport, M. M.; Schuman, J. *J Pharmacol Methods* 8(4):245-254 (11 refs).

A nonrestraining waveguide chamber designed to work with focussed 2450 MHz microwave (MW) radiation to kill small rodents rapidly and without stress to the animals is described. The design is based on the observation that a rodent will preferentially enter a darkened hole (e.g., in the broad face of the waveguide chamber device) with a delay time of 1 sec after being placed on a lighted platform adjacent to the chamber. The MW generator to which the waveguide chamber is attached must have a minimum 3.5 kW output power to properly heat the mass of the small rodent head within the time limit of 1 sec msec required for the accurate measurement of basal concentrations of rapidly modulated neurochemical indices. For maximum coupling of MW energy to the rodent brain, animal placement must be at a distance of 1/4 wavelength from the closed end of the waveguide. To insure accurate positioning of a standing wave of MW radiation at this location, a single screw tuner waveguide section is inserted into the waveguide system between the magnetron and the chamber. A positioning cup, consisting of a plastic cylindrical tube with a rounded end, is placed through the waveguide to optimally position the animal head within the energy field. Two versions of the waveguide have been extensively tested: a small WR-184 chamber suitable for either the neonate mouse or rat (up to 10 g), and a WR-430 chamber for use with the adult mouse and small rats (to 50 g). The center of the entrance hole is positioned at distances of 2.9 and 3.69 in from the terminal end of the WR-184 and the WR-430 chambers, respectively.

- 0687 PULSING ELECTROMAGNETIC FIELDS IN THE TREATMENT OF NON-UNION OF FRACTURES. (Eng.) Caullay, J. M. (Orthopaedic and Accident Unit, Royal Infirmary, Glasgow, Scotland, March 1983). *J R Coll Surg Edinb* 27(2):102-103 (11 refs).

Four cases of non-union of the tibia treated successfully with pulsing electromagnetic fields (PEMF) are

FCAP 4ER, England. 1. 1984-1985. 2. 1986-1987. 3. 1988-1989. 4. 1990-1991. 5. 1992-1993. 6. 1994-1995. 7. 1996-1997. 8. 1998-1999. 9. 2000-2001. 10. 2002-2003. 11. 2004-2005. 12. 2006-2007. 13. 2008-2009. 14. 2010-2011. 15. 2012-2013. 16. 2014-2015. 17. 2016-2017. 18. 2018-2019. 19. 2020-2021. 20. 2022-2023. 21. 2024-2025. 22. 2026-2027. 23. 2028-2029. 24. 2030-2031. 25. 2032-2033. 26. 2034-2035. 27. 2036-2037. 28. 2038-2039. 29. 2040-2041. 30. 2042-2043. 31. 2044-2045. 32. 2046-2047. 33. 2048-2049. 34. 2050-2051. 35. 2052-2053. 36. 2054-2055. 37. 2056-2057. 38. 2058-2059. 39. 2060-2061. 40. 2062-2063. 41. 2064-2065. 42. 2066-2067. 43. 2068-2069. 44. 2070-2071. 45. 2072-2073. 46. 2074-2075. 47. 2076-2077. 48. 2078-2079. 49. 2080-2081. 50. 2082-2083. 51. 2084-2085. 52. 2086-2087. 53. 2088-2089. 54. 2090-2091. 55. 2092-2093. 56. 2094-2095. 57. 2096-2097. 58. 2098-2099. 59. 2100-2101. 60. 2102-2103. 61. 2104-2105. 62. 2106-2107. 63. 2108-2109. 64. 2110-2111. 65. 2112-2113. 66. 2114-2115. 67. 2116-2117. 68. 2118-2119. 69. 2120-2121. 70. 2122-2123. 71. 2124-2125. 72. 2126-2127. 73. 2128-2129. 74. 2130-2131. 75. 2132-2133. 76. 2134-2135. 77. 2136-2137. 78. 2138-2139. 79. 2140-2141. 80. 2142-2143. 81. 2144-2145. 82. 2146-2147. 83. 2148-2149. 84. 2150-2151. 85. 2152-2153. 86. 2154-2155. 87. 2156-2157. 88. 2158-2159. 89. 2160-2161. 90. 2162-2163. 91. 2164-2165. 92. 2166-2167. 93. 2168-2169. 94. 2170-2171. 95. 2172-2173. 96. 2174-2175. 97. 2176-2177. 98. 2178-2179. 99. 2180-2181. 100. 2182-2183. 101. 2184-2185. 102. 2186-2187. 103. 2188-2189. 104. 2190-2191. 105. 2192-2193. 106. 2194-2195. 107. 2196-2197. 108. 2198-2199. 109. 2200-2201. 110. 2202-2203. 111. 2204-2205. 112. 2206-2207. 113. 2208-2209. 114. 2210-2211. 115. 2212-2213. 116. 2214-2215. 117. 2216-2217. 118. 2218-2219. 119. 2220-2221. 120. 2222-2223. 121. 2224-2225. 122. 2226-2227. 123. 2228-2229. 124. 2230-2231. 125. 2232-2233. 126. 2234-2235. 127. 2236-2237. 128. 2238-2239. 129. 2240-2241. 130. 2242-2243. 131. 2244-2245. 132. 2246-2247. 133. 2248-2249. 134. 2250-2251. 135. 2252-2253. 136. 2254-2255. 137. 2256-2257. 138. 2258-2259. 139. 2260-2261. 140. 2262-2263. 141. 2264-2265. 142. 2266-2267. 143. 2268-2269. 144. 2270-2271. 145. 2272-2273. 146. 2274-2275. 147. 2276-2277. 148. 2278-2279. 149. 2280-2281. 150. 2282-2283. 151. 2284-2285. 152. 2286-2287. 153. 2288-2289. 154. 2290-2291. 155. 2292-2293. 156. 2294-2295. 157. 2296-2297. 158. 2298-2299. 159. 2300-2301. 160. 2302-2303. 161. 2304-2305. 162. 2306-2307. 163. 2308-2309. 164. 2310-2311. 165. 2312-2313. 166. 2314-2315. 167. 2316-2317. 168. 2318-2319. 169. 2320-2321. 170. 2322-2323. 171. 2324-2325. 172. 2326-2327. 173. 2328-2329. 174. 2330-2331. 175. 2332-2333. 176. 2334-2335. 177. 2336-2337. 178. 2338-2339. 179. 2340-2341. 180. 2342-2343. 181. 2344-2345. 182. 2346-2347. 183. 2348-2349. 184. 2350-2351. 185. 2352-2353. 186. 2354-2355. 187. 2356-2357. 188. 2358-2359. 189. 2360-2361. 190. 2362-2363. 191. 2364-2365. 192. 2366-2367. 193. 2368-2369. 194. 2370-2371. 195. 2372-2373. 196. 2374-2375. 197. 2376-2377. 198. 2378-2379. 199. 2380-2381. 200. 2382-2383. 201. 2384-2385. 202. 2386-2387. 203. 2388-2389. 204. 2390-2391. 205. 2392-2393. 206. 2394-2395. 207. 2396-2397. 208. 2398-2399. 209. 2400-2401. 210. 2402-2403. 211. 2404-2405. 212. 2406-2407. 213. 2408-2409. 214. 2410-2411. 215. 2412-2413. 216. 2414-2415. 217. 2416-2417. 218. 2418-2419. 219. 2420-2421. 220. 2422-2423. 221. 2424-2425. 222. 2426-2427. 223. 2428-2429. 224. 2430-2431. 225. 2432-2433. 226. 2434-2435. 227. 2436-2437. 228. 2438-2439. 229. 2440-2441. 230. 2442-2443. 231. 2444-2445. 232. 2446-2447. 233. 2448-2449. 234. 2450-2451. 235. 2452-2453. 236. 2454-2455. 237. 2456-2457. 238. 2458-2459. 239. 2460-2461. 240. 2462-2463. 241. 2464-2465. 242. 2466-2467. 243. 2468-2469. 244. 2470-2471. 245. 2472-2473. 246. 2474-2475. 247. 2476-2477. 248. 2478-2479. 249. 2480-2481. 250. 2482-2483. 251. 2484-2485. 252. 2486-2487. 253. 2488-2489. 254. 2490-2491. 255. 2492-2493. 256. 2494-2495. 257. 2496-2497. 258. 2498-2499. 259. 2500-2501. 260. 2502-2503. 261. 2504-2505. 262. 2506-2507. 2

[illegible]

069 THE EFFECT OF A
IRRADIATION
NEAR-IR LASER SURFACE TREATMENT ON
BRASS COMPONENTS. J. M. HARRIS,
Las Biophysics Branch, Department
Health Effects Research, Health
Phys., NIOSH, Cincinnati, Ohio.
The effect of

A model of the cell surface is developed to determine the effect of an externally applied electric field on the interaction between negative charges embedded in the cell membrane and positive ions (counter-ions) trapped near the surface. The cell is assumed to be an immovable hemisphere with a continuous distribution of charges on the surface. A homogeneous electric field is applied parallel to the surface on which the hemisphere is affixed. At a time period after the application of an external electric field that is long compared to the relaxation time of the surrounding ions but short compared to the time needed for movement of the charged molecules within the surface, the electric field due to counter-ion polarization can be estimated at any point on the cell surface. The electric field was evaluated at each point on the surface under the assumption that $qaE_0 \ll kT$ where q is the charge of the ion near the surface, a is the radius of the cell, E_0 is the external electric field, k is Boltzmann's constant, and T is the absolute temperature. Plots of the electric field are given as a function of cell surface potentials from 10 to 80 mV, temperatures from 5 to 37°C, and electrolytes. The solution for the electric field due to ion polarization is independent of the cell radius for small applied fields (approx. 1 V/cm); if $qaE_0 < kT$, it will depend on the cell radius and polar spherical coordinate. A more refined model would include distributions of discrete charges on the cell surface instead of a continuous distribution, allowance for redistribution of surface charges with the field, and the effects of bound water. The model presented does predict a force due to counter-ion distribution polarization that could significantly affect the charges that are embedded in the membrane.

0691 LEUKEMIA IN WORKERS EXPOSED TO ELECTRICAL AND MAGNETIC FIELDS (LETTER TO EDITOR). (Eng.) Wright, W. E. (Dept. Family and Preventive Medicine, Univ. Southern California Sch. Medicine, Los Angeles, CA 90033); Peters, J. M.; Mack, T. M. *Lancet* 2(8308):1160-1161; 1982 (11 refs).

Leukemia incidence in Los Angeles County from 1972 to 1979 in white males occupationally exposed to electrical and magnetic fields was studied following reports suggesting an increased risk for leukemia with exposure to electrical and magnetic fields. There were 35 cases of all leukemias among occupationally exposed men; the proportional incidence ratio (PIR=observed/expected x 100) was 128.6. For acute leukemias, the number of cases was 23 and the PIR 172.6. For acute myelogenous leukemias (AML), the number of cases was 22, and the PIR 207.1. The data indicate that there is a trend toward increased PIRs in occupationally exposed males and that the risk is greatest for AML. AML in power linemen and telephone linemen and the cumulative PIRs for all electrical jobs for acute leukemia and AML are significant.

0692 EFFECTS OF LOW-LEVEL MICROWAVE RADIATION ON THE EYE OF THE CRAYFISH. (Eng.) Munemori, J. (Dept. Electrical Engineering, Osaka Inst. Technology, Gokiso, Asaka, Osaka, Japan); Ikeda, T. *Med Biol Eng Comput* 21:193-197; 1982 (4 refs).

The biological effects of low-level microwave (MW) radiation were investigated in the optic nerves of crayfish (*Procambarus clarkii*). Optic nerves were inserted into a waveguide and irradiated at a power of 1 mW for 1 min. MW power was provided by an HP Model 8620C sweep oscillator operating at 9.4 GHz (continuous wave). Electrodes were inserted into the optic nerve from the side of the waveguide to measure the spontaneous discharge without disturbing the electromagnetic field. The spontaneous discharge was recorded for 1 min before irradiation, during 1 min of irradiation, and after the power was turned off. Although the amplitude of the waves and the mean value of the interspike intervals were not significantly changed by irradiation, the distribution of the intervals (variance) decreased gradually at the beginning of exposure and then increased and approached pre-irradiation values. The calculated power density at the crayfish eye irradiated under these conditions was 0.004 W/cm² and the calculated temperature increase in the eye for 1 min of irradiation was 0.01°C. Thus the observed response, which was obtained at a power level lower than Japanese maximum permissible exposure levels, was not due to a thermal effect.

0693 MORTALITY FROM LEUKEMIA IN WORKERS EXPOSED TO ELECTRICAL AND MAGNETIC FIELDS (LETTER TO EDITOR). (Eng.) Milham, S. (Washington State Dept. Social and Health Services, Olympia, WA 98504). *N Engl J Med* 307(4):344-345; 1982.

When proportionate mortality ratios (PMRs=observed x 100) standardized by age and year of death were calculated for 158 cause-of-death groups in 218 occupational classes in Washington state from 1950 through 1979, leukemia mortality in all workers was found to be greater than expected among men 20 years old whose occupations required them to work with electric or magnetic fields. The PMR for leukemia ranged from 67 (welders and flame cutters) to 137 (power station operators) in the 11 occupational categories presumed exposure to electric and magnetic fields and averaged 137. The PMR was elevated among occupations. For acute leukemia, the PMR was 137 (streetcar and subway motorman) to 207 (power station and radio repairmen) and averaged 137. The number of expected total and acute leukemia cases ranged from 1.7 to 37 and from 0.4 to 10.8, respectively. The author states that the available literature on occupational exposure to electrical and magnetic fields has not mentioned carcinogenesis; however, these findings suggest a causal relationship between electric and magnetic fields and leukemia.

The first of these is the *Journal of the American Medical Association* (JAMA), which has been the most influential journal in the field of general internal medicine. The second is the *New England Journal of Medicine* (NEJM), which has been the most influential journal in the field of clinical medicine. The third is the *Lancet*, which has been the most influential journal in the field of clinical medicine. The fourth is the *British Medical Journal* (BMJ), which has been the most influential journal in the field of clinical medicine. The fifth is the *Annals of Internal Medicine* (AIM), which has been the most influential journal in the field of clinical medicine. The sixth is the *Journal of the American College of Physicians* (JGIM), which has been the most influential journal in the field of clinical medicine. The seventh is the *Journal of the American Geriatrics Society* (JAGS), which has been the most influential journal in the field of clinical medicine. The eighth is the *Journal of the American Society of Nephrology* (JASN), which has been the most influential journal in the field of clinical medicine. The ninth is the *Journal of the American Society of Hypertension* (JASH), which has been the most influential journal in the field of clinical medicine. The tenth is the *Journal of the American Society of Endocrinology* (JASE), which has been the most influential journal in the field of clinical medicine. The eleventh is the *Journal of the American Society of Radiology* (JASR), which has been the most influential journal in the field of clinical medicine. The twelfth is the *Journal of the American Society of Pathology* (JASP), which has been the most influential journal in the field of clinical medicine. The thirteenth is the *Journal of the American Society of Microbiology* (JASM), which has been the most influential journal in the field of clinical medicine. The fourteenth is the *Journal of the American Society of Pharmacology and Therapeutics* (JASPT), which has been the most influential journal in the field of clinical medicine. The fifteenth is the *Journal of the American Society of Toxicology* (JAST), which has been the most influential journal in the field of clinical medicine. The sixteenth is the *Journal of the American Society of Nutrition* (JASN), which has been the most influential journal in the field of clinical medicine. The seventeenth is the *Journal of the American Society of Human Genetics* (JASHG), which has been the most influential journal in the field of clinical medicine. The eighteenth is the *Journal of the American Society of Human Biology* (JASHB), which has been the most influential journal in the field of clinical medicine. The nineteenth is the *Journal of the American Society of Human Development* (JASHD), which has been the most influential journal in the field of clinical medicine. The twentieth is the *Journal of the American Society of Human Evolution* (JASHE), which has been the most influential journal in the field of clinical medicine.

As a result, the 1980s have been characterized by a general trend toward the use of more complex, integrated systems of management. Several of the factors that have contributed to this trend are:

- 1. The increasing complexity of the business environment.
- 2. The increasing demand for quality and customer service.
- 3. The increasing need for cost control and efficiency.
- 4. The increasing need for innovation and flexibility.
- 5. The increasing need for communication and collaboration.

As a result of these factors, many organizations have adopted integrated systems of management that combine the best of all worlds. These systems are designed to provide a comprehensive view of the organization's operations and to enable management to make more informed decisions. Some of the most common integrated systems of management are:

- 1. Total Quality Management (TQM): A system of management that focuses on continuous improvement and customer satisfaction.
- 2. Just-in-Time (JIT): A system of management that focuses on reducing inventory and improving efficiency.
- 3. Lean Manufacturing: A system of management that focuses on eliminating waste and improving productivity.
- 4. Six Sigma: A system of management that focuses on reducing defects and improving quality.
- 5. Balanced Scorecard: A system of management that focuses on measuring performance from multiple perspectives.

These integrated systems of management have been shown to be effective in improving organizational performance and achieving long-term success. As a result, they have become widely adopted by organizations around the world.

time of the mice to MW radiation was assessed by measuring the interval between the onset of exposure and the time for EHL to reach a point corresponding to $(1-1/e)$ of the total change (approx. 63% above baseline). The response time decreased as a power function with increasing SAR, from 9 min at 19 W/kg to 3.9 and 3.4 min at 68 and 194 W/kg, respectively. When deep-body temperature was measured in restrained mice during exposure to MW radiation (incident power of 1 to 10 W), a direct correlation between the rate of increase in deep body temperature and SAR was observed: the temperature increased by 0.0004 C/sec for each W/kg elevation in SAR. The results suggest that control of EHL in the mouse is highly sensitive to the rate of heat absorption and support the hypothesis that the mammalian heat-dissipating system is highly affected by the rate of temperature increase (i.e., temperature regulation as opposed to thermoregulation).

- 0699 EFFECTS OF ELECTROMAGNETIC STIMULI ON BONE AND BONE CELLS IN VITRO: INHIBITION OF RESPONSES TO PARATHYROID HORMONE BY LOW-ENERGY LOW-FREQUENCY FIELDS. (Eng.) Luben, R. A. (Div. Biomedical Sciences and Dept. Biochemistry, Univ. California, Riverside, CA 92521); Cain, C. D.; Chen, M. C.-Y.; Rosen, D. M.; Adey, W. R. *Proc Natl Acad Sci USA* 79:4180-4184; 1982 (35 refs.).

The effects of clinically useful pulsed electromagnetic fields (PEMF) on cultures of the osteoblast-like mouse cell line MMB-1 were studied and the responses of the cells to hormones that either do or do not appear to act primarily via plasma membrane receptors were examined. PEMFs were produced by the paired square Helmholtz coils of the Bi-Osteogen clinical field generator. In one configuration, a continuous train of single pulses was produced at a frequency of 72 Hz. The second system consisted of bursts of 4-kHz pulses lasting 5 msec and repeated at a 15 Hz rate. Both fields generated an electrical gradient of 1.0 mV/cm. Exposure to both PEMFs inhibited accumulation of cAMP stimulated by parathyroid hormone (PTH) or osteoclast-activating factor (OAF) by decreasing the hormonal effects on adenylate cyclase in the cell membrane. Inhibition of PTH and OAF responsiveness persisted after the cells were removed from the fields. The catalytic activity of adenylate cyclase, as determined by fluoride activation, was not changed by exposing cell cultures to either PEMF. The inhibition of cAMP levels was attributed to field effects on cell surface receptors for the hormones. Neither field altered the effects on collagen synthesis of 1,25-dihydroxyvitamin D₃, a hormone with a cytoplasmic receptor. Another cell surface effect was the blocking of PTH inhibition of collagen synthesis by the fields. No significant difference was seen in the effects of the two PEMFs. These experiments substantiated the hypothesis that field effects are mediated through the osteoblast cell membrane by interferences with hormone-receptor binding or recep-

tor coupling with adenylate cyclase.

- 0700 LOCAL HYPERTHERMIA FOR TREATMENT OF PROSTATIC CARCINOMA OF THE PROSTATE: A PRELIMINARY REPORT. (Eng.) Yerushalmi, A. (Radiation Inst., Weizmann Inst. Science, Rehovot 76100, Israel); Serravalle, C.; Leib, Z.; Fishelovitz, Y.; Rozovsky, E.; Stein, J. A. *Prostate* 3:623-630; 1982 (28 refs.).

After extensive animal experiments, 15 patients with prostatic carcinoma received a total of 146 treatments of local deep microwave hyperthermia (LDMWH, 2.45 GHz) either alone or in combination with radiotherapy (6,200 rads) or hormonal therapy (DES, 3 mg/day). LDMWH was delivered from a probe inserted into the rectal cavity. Tumors were heated to 42-43°C while non-invaded tissues were maintained at a temperature below 32°C. A total of 6 to 9 60-min LDMWH treatments were given at 2-3 day intervals. Treatments were well tolerated by all of the patients and subjective and objective improvements were recorded in all cases.

- 0701 INTERACTION OF MICROWAVE RADIATION WITH TURKEY SPERM. (Eng.) Hall, C. A. (Lab. Environmental Biophysics, Natl. Inst. Environmental Health Sciences, Research Triangle Park, NC 27709); Galvin, M. J.; Thaxton, J. P.; McRee, D. L. *Environ Biophys* 20(2):145-152; 1982 (17 refs.).

Mature turkey sperm were exposed in vitro to 2.45 GHz continuous wave microwave (MW) radiation in a temperature controlled waveguide apparatus. Temperature was maintained at $40.0 \pm 0.5^\circ\text{C}$. Sperm suspensions were exposed for 30 min at an average specific absorption rate (SAR) of either 1, 10, or 50 mW/g. Samples were stirred during exposure by magnetic stirrers mounted below the waveguide to eliminate variation in intrasample temperatures. The following parameters were examined before and after MW exposure: percentage viability, percentage abnormal sperm, and release of the enzymes lactate dehydrogenase (LDH) and glutamic oxalo transaminase (GOT). Removal of the seminal plasma had no effect on spermatocyte viability; thus, the results are from washed spermatocytes only. The time to perform the experiments and the stirring of the samples produced no observed changes in viability of the sperm or enzyme release. Viability was 90% or above for all exposed and control groups and was not significantly affected by in vitro exposures at SARs of 1, 10, or 50 mW/g. There were no significant differences between treatment groups in the percentage of abnormal sperm. Release of the cytoplasmic enzymes LDH and GOT was not significantly altered by MW radiation.

Current Literature

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- 0703 COAGULATION OF MALIGNANT TUMORS AFTER LOCALIZED MICROWAVE HYPERTHERMIA. (Eng.) J. W. F. W. (Physiologisches Inst., Univ. Mainz, Postfach 21, D-6500 Mainz, W. Germany); Otte, H. (Inst. f. Radiat. Environ. Biophys. D-43189-Krefeld, W. Germany).

Changes in the oxygenation of tumor tissue during localized microwave (MW) hyperthermia treatment of fibrosarcoma tumors in rats were studied. Tumors were grown on the hind feet of 270-300 g inbred Sprague-Dawley rats of both sexes until tumor volumes reached 1.5-5.0 ml (10-17 days after implantation). Observations were performed on a total of 40 tumor-bearing rats anesthetized by ip injection of sodium pentobarbital. Tumors were heated to 40, 43, and 45 C for 30 min by application of 2450 MHz MW radiation produced by a Radarmed type 12 S 20 generator. Tumor temperatures were monitored with miniaturized thermocouples and the power of the generator was adjusted as required to maintain tumor temperatures constant to within 0.1 C. Core temperatures, mean arterial blood pressure, and blood gases of the left carotid artery were also monitored. After heating, tumor tissue biopsies were taken to measure the oxygenation state which was determined by the oxyhemoglobin (HbO₂) saturation of single red blood cells within tumor microvessels with diameters up to 12 µm using a cryophotometric method. HbO₂ saturation varied from 0 to HbO saturation percent with a mean value of 51 sat.% in 11 control tumors. After 43 C-hyperthermia, mean saturation increased to 56 sat.% (11 tumors). However, mean tumor oxygenation decreased to 47 and 24 sat.% after 43 and 45 C hyperthermia, respectively. No changes in core temperature, blood pressure, or blood gases were recorded. Lower HbO₂ saturation values at 45 C were attributed to decreased nutritive blood flow. Metabolic needs of the tumor tissue such as oxygen consumption seem to have a minor effect on the intercapillary HbO₂ saturation distribution.

- 0704 SCIENTIFIC AND HYGIENIC ISSUES IN BIOLOGICAL RESEARCH ON MICROWAVES: TOWARD RAPPROCHEMENT BETWEEN EAST AND WEST. (Eng.) Justesen, D. R. (Dept. Psychiatry, Univ. Kansas Sch. Medicine, Kansas City, Kansas 66103). Radio Science 17(5S):1S-12S; 1982 (74 refs).

Many issues and controversies separate the experimental radiobiologist and the hygienist from the goal of attaining a concordant view of biological effects of exposure to microwaves and other radio-frequency electromagnetic (RFEM) fields. Although the strongest notes of discord are struck by East-West differences (e.g., recommended limits with respect to exposure of human populations to RFEM fields are generally orders of magnitude more stringent in the USSR than in the U.S.), there are discordant notes as well within national boundaries. Selected problems are addressed in terms of semantic,

tactical, logistic, and strategic issues, some of which in some measure have import for the entire community of radio scientists. Semantic issues include the false agreement or disagreement arising from failure to achieve common definitions of terms. The tactical issues are those of the proper experiment: field strength, densitometry, and so forth. The pitfalls of interdisciplinary research are the logistical burden and problems of communication between two or more disciplines. Strategic issues deserving of study on a global level are the nature of

- 0705 COHERENT OSCILLATIONS IN BIOLOGICAL SYSTEMS: INTERACTION WITH EXTREMELY LOW FREQUENCY FIELDS. (Eng.) Kaiser, F. (Inst. Theoretical Physics, Univ. Stuttgart, Pfaffenwaldring 57, D-7000 Stuttgart 80, W. Germany). Radio Science 17(5S):17S-22S; 1982 (27 refs).

Prehlich's concept of coherently excited long wavelength electric vibrations in the 10-100-Hz region associated with metastable states with a very high dipole moment in biological membranes has been the basis for explaining the extraordinary high sensitivity of certain biological systems to extremely weak electromagnetic signals. In this model, long-range collective interactions within the membrane may lead to oscillatory biochemical reactions. The resulting slow chemical oscillation is connected to a corresponding electric vibration by means of the large dipole moments of reaction-activated enzymes. Thus a macroscopic oscillating polarization is built up, causing large regions to oscillate coherently in the 10 to 100-Hz region (e.g., EEG activity). The remaining (unscreened) polarization causes the system to exhibit a ferroelectric instability. The nonlinear kinetic equations describing the system are discussed. Extremely low frequency fields interact with the limit cycle oscillation, which can be caused to collapse for certain frequencies and intensities of the stimulation. This leads to the onset of propagating pulses even for an extremely weak stimulation. There is increasing experimental support for the rather speculative model and for the existence of biological effects when systems are exposed to electromagnetic waves. Furthermore, correspondence between this model and nerve impulse generating models has been established.

- 0706 QUANTUM SOLID STATE MECHANISMS OF NONTHERMAL BIOLOGICAL EFFECTS OF ELECTROMAGNETIC RADIATION WITH EMPHASIS ON LOCAL SUPERCONDUCTIVITY. (Eng.) Achimowicz, J. (Military Inst. Aviation Medicine, Warsaw, Poland). Radio Science 17(5S):23S-36S; 1982 (36 refs).

Quantum solid state mechanisms of nonthermal biological effects of nonionizing electromagnetic radiation are

reviewed, and an hypothesis concerning mechanisms based on biological superconductivity is presented. Classical and quantum mechanisms of bioeffects are compared, stressing the necessity of not only considering quantum absorption, transfer, and conversion of radiant energy in biological systems, but also of appropriate systems modeling. There is a need for developing quantum models of the biological solid state on the supramolecular level to fill the gap between molecular and cell biology. The supramolecular models of macromolecules and enzyme complexes are reviewed. The high-temperature superconductivity problem in organic systems is discussed, with stress on the importance of system structure and the excitation quasi-particle (phonon and electron) spectra relationship. New mechanisms of enzymatic activity assuming enzyme-substrate complex electron spectrum instability induced by electron- and phonon-mediated electron-electron interaction are proposed. Since this quantum cooperative phenomenon is the possible origin of specificity and efficiency of enzyme action, it is extremely sensitive to system-generated electromagnetic fields, which gives the possibility of enzymatic regulation and also may explain some nonthermal resonant bioeffects. In systems containing superconducting regions, the processes of electron transport depend strongly on magnetic and electromagnetic fields which can be the origin of biological effects of nonionizing radiation. Local superconductivity coherent electron states) and the Josephson effects are discussed as the possible mechanisms of bioeffect, such as the observed sensitivity of small animals to very weak magnetic fields.

0706 MEASUREMENTS OF ELECTRIC AND MAGNETIC STRAY FIELDS PRODUCED BY VARIOUS ELECTRODES OF 27-MHz DIATHERMY EQUIPMENT. (Eng.) Kalliomaki, P. L. (Inst. Occupational Health, SF-00290 Helsinki 29, Finland); Nietanen, M.; Kalliomaki, K.; Koistinen, O.; Valtonen, E. Radio Science 17(5S):29S-34S; 1982 (5 refs).

To investigate the exposure of the physiotherapist and to unprescribed tissues, electric and magnetic stray fields were measured around 3 types of commercially available diathermy units (3 Siemens Ul-tratherm 608 units, 3 Curapulse Curamed 418 units, and 1 Diapulse D 401 unit) with 4 typical electrodes in 6 routine therapeutic treatments. The subjects were 2 men and 2 women. Field strengths were determined at the point of treatment and at 14 locations close to the patient's body, and as a function of distance from the electrodes. The radiation dose setting was at position 1 for continuous wave power and at positions 5-7 for pulsed power. At a distance of 0.6 m from the diathermy units, the power density was less than 10 W/m². The results showed that the diathermy devices are very similar with respect to stray fields, but there are great differences between the electrodes during specific treatments. When the unit was well tuned, the relative

output power of the equipment was found to be proportional to the dose scale readings. The stray fields were found to be only 7.1 V/m and 0.1 mT in the respective instruction manuals. The measured values of electric and magnetic field strengths are tabulated. The results are discussed to select proper electrodes for different therapeutic treatments, as they indicate which electrodes would have minimum stray fields.

0707 ELF MAGNETIC FIELDS IN ELECTROSTEEL AND WELDING INDUSTRIES. (Eng.) Lovsund, P. (Dept. Biomedical Engineering, Linköping Univ., SE-581 85 Linköping, Sweden); Öberg, R. A.; Nilsson, J. E. G. Radio Science 17(5S):35S-38; 1982 (13 refs).

In order to obtain a realistic basis for future studies of the bioeffects of low-frequency magnetic fields present in industrial environments, magnetic fields were mapped for a number of welding and steel processes. All of the measurements were performed at points selected to obtain the closest possible impressions of the fields to which the workers are exposed. Measurements were carried out with the aid of a F W Bell 610Z gaussmeter operating within 0.1 kHz and the dynamic region 0.1 mT-10 T, which is 10⁴ G. The industrial measurements comprised only the magnetic component of the field as the processes studied require high currents even though low voltage is used. Field flux densities in the range 0-10 mT at mostly 50 Hz were found in electric welding and electric steel industries. Both the magnetic flux density and the frequency may be very high (up to 10 kHz) near induction heaters, and a study which will include electric field measurements is planned. In order to improve knowledge on how low-frequency magnetic fields affect man in industrial environments, it is important to simulate the flux density data measured in industry in the laboratory. As understanding of how the magnetic field influences biological structures at the cellular level increases, it will be possible to predict effects at higher levels and to establish more reliable threshold values.

0708 POPULATION EXPOSURE TO THE AM AND THE BROADCAST RADIATION IN THE UNITED STATES. (Eng.) Tell, R. A. (Office of Radiation Programs, Electromagnetic Radiation Analysis Branch, EPA, Las Vegas, NV 89114); Mantiply, L. D. Radio Science 17(5S):39S-47S; 1982 (13 refs).

Nearly 11,000 individual broadcast signal field intensities were determined at 374 measurement sites distributed throughout 12 large cities (Boston, Atlanta, Miami, New York, Philadelphia, Chicago, Las Vegas, Washington, San Diego, Portland, Houston, and Los Angeles) to estimate population exposure to the

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10.40 MHz, and the ^{13}C chemical shift was calibrated with $\text{Ca}^{13}\text{CO}_3$ (converged with the methyl group).

- 9710 HOW, CORRELL, JR., R. C. (1913-)
FIELD, IN. PHYS. & ASTRON. 1940-41
Lee, J.-H. (Dept. Mathematics, University of
Science, Michigan State Univ., E. Lansing, Mich.)
M. Radio Science 1945, 19, 50-51, 1946, 19, 1-2

An inexpensive rugged implantable electric field probe with an interference-free lead wire system was constructed to measure the induced electric fields in a phantom model of man irradiated by waves of various frequencies. The probe consisted of a short dipole loaded with a zero-bias microwave (MW) diode, and the interference-free lead wires were constructed with two series of lumped resistors of 3 kohm. Characteristics of the probe were checked by measuring the induced electric fields in irradiated, electrically small cubes filled with phantom material. The measured results agreed well with theoretical results obtained from the tensor integral equation method. A phantom model of man scaled to 1/5 dimensions of a typical man made of thin Plexiglas was filled with phantom material of appropriate conductivity and permittivity and placed in a large MW anechoic chamber and exposed to 500-3500 MHz traveling electromagnetic waves incident normally from front to back. Induced electric fields were probed over 28 locations in one side of the model and the distribution of the measured electric fields was compared with the distribution of theoretical results obtained numerically from the tensor integral equation methods. While a qualitative agreement was obtained between experiment and theory, the agreement tended to deteriorate at lower frequencies. This may be due to the fact that the magnetic mode of induced electric field starts to dominate the electric mode as the frequency becomes lower than

- 0711 IRRADIATION OF DNA IN THE PRESENCE OF
OF HUMANS AND ANIMALS IN THE PRESENCE OF
OF A SMALL LOOP ANTENNA. (Ph.D. Thesis, 1982,
(Dept. Electrical Engineering, Univ. of Utah,
Lake City, UT 84112); Iskander, M. A.; Hammad, A. H.;
Massoud, H. Radiat. Environ. Biophys. 1982, 11, 1-10.
1982 (23 refs).

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an increase in the average SAR values was generally observed. In spite of the complicated nature of the near fields, the absorption characteristics can be explained in terms of the incident radiation. At all frequencies, excessive heating occurs at the surface of the spheroid while a limited absorption occurs in the central region around the major axis. This result is of particular importance in hyperthermia, where efforts are being directed towards achieving deep-tissue heating by a coaxial coil carrying radiofrequency power at about 27 MHz.

- 0712 STUDIES OF MICROWAVE ABSORPTION IN LIQUIDS BY OPTICAL HETERODYNE DETECTION OF THERMALLY INDUCED REFRACTIVE INDEX FLUCTUATIONS. (Eng.) Davis, C. C. (Electrical Engineering Dept., Univ. Maryland, College Park, MD 20742); Swicord, M. L. *Radio Science* 17(5S):85S-94S; 1982 (6 refs).

A new technique is described for performing microwave (MW) absorption spectroscopy of transparent or translucent media, particularly liquids, which directly measures the frequency dependence of power absorbed in the sample. In this technique, called phase fluctuation optical heterodyne spectroscopy, the refractive index fluctuation produced in a sample when its temperature rises as a result of absorption of MW radiation is measured. This refractive index fluctuation produces a phase fluctuation in a single-frequency laser beam passing through the sample. For a small temperature increase, the magnitude of the induced phase fluctuation is directly proportional to the temperature increase, and is a direct measure of the amount of absorbed power. The phase fluctuation is measured by heterodyning the laser beam which traverses the sample with a reference beam derived from the same single-frequency laser. Preliminary experiments on water and ethanediol yield absorption spectra that are consistent with those obtained in previous investigations using conventional techniques.

- 0713 THERMOGRAPHIC ANALYSIS OF WAVEGUIDE-IRRADIATED INSECT PUPAE. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508); Hammer, W. C. *Radio Science* 17(5S):95S-104S; 1982 (8 refs).

A high-resolution thermographic imaging system was used to study radiofrequency (RF) absorption patterns in the yellow mealworm, *Tenebrio molitor* L., for waveguide irradiation situations. Early-stage pupae (1-3 days old) of the yellow mealworm without visible defects were mounted inside a right-angle, waveguide E bend and irradiated through longitudinal slots cut in the broad wall of the E bends. Use of the E bends was required by the addition of a closeup lens assembly mounted on the front of the

thermographic imaging device, a Spectotherm Model 900, which was used to obtain the magnitude and spatial distribution of absorbed microwave (MW) energy at three frequencies. At 1.3 and 5.95 MHz, the MW source was a sweeper/oscillator (Arling 100) that was used to drive traveling wave tube amplifiers (Semidyne); at 10 GHz, a Gunn oscillator (General Microwave CMF-420AE) supplied the power. Measured power levels were 25 W, 1.0 W, and 25 mW, respectively, at 1.3, 5.95, and 10 GHz. The thermographic images show good resolution of the irradiated pupae; many of the thermograms clearly show the head, legs, and other features. Distinct differences in electrical properties exist between the various sections of the insect, particularly between the abdomen and the other two sections. These thermographic measurements suggest that more theoretical work is needed to properly model the nonhomogeneous nature of the actual pupa.

- 0714 MILLIMETER WAVE IRRADIATION AND MEASUREMENT SYSTEM FOR CELL SUSPENSIONS. (Eng.) Tamburello, C. C. (Inst. Elettrotecnica & Elettronica, 90128 Palermo, Italy); Zantorini, L. *Radio Science* 17(5S):105S-110S; 1982 (6 refs).

The high water content of cell suspensions, which is necessary for cell survival, creates certain problems in the measurement of electric parameters in the millimeter wave band. By feeding microwave energy through the sample holder bottom, it has been possible to make accurate measurements of the sample mismatch using a highly sensitive null interferometer. Two measurement systems have been developed; the first, which utilizes a tunable klystron in the 65-73 GHz range, allows precise measurements at fixed frequencies; the second, which utilizes two swept impact avalanche transit time (IMPATT) sources covering the 66-85 GHz range, allows rapid parameter measurements over a wide frequency range but with reduced precision. Reflection characteristics of a cell sediment can be accurately derived in the 60-90 GHz frequency band. These results may then be utilized in cooperation with biologists for analyses of correlations between electrical and biological effects, in an effort to better understand the mechanism of microwave interaction at the cellular level and to help define a physical model of these phenomena.

- 0715 A MICROWAVE METHOD FOR ESTIMATING AN ABSOLUTE VALUE OF AVERAGE LUNG WATER. (Eng.) Iskander, M. F. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, Utah 84112); Durney, G. H.; Bragg, D. C.; Ovard, B. H. *Radio Science* 17(5S):111S-117S; 1982 (21 refs).

Current Literature

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The ability to measure lung water is an essential diagnostic technique for the diagnosis of virtually all lung diseases. A microwave (MW) transmission method for calculating the absolute value of the water content of the lung has been developed, using computerized axial tomography to obtain a transverse cross-sectional image of the thorax showing the dimensions and the relative positions of the organs and the MW applicators. The electromagnetic field problem is then solved numerically using the method of moments. The numerical procedure was evaluated by carrying out detailed calculations for a human cross-section, and the cross-section of a dog's thorax. The transmission coefficient can be directly related to the average amount of total water content in the lung since the mismatch between the MW applicators and the patient's skin is found to be highly insensitive to the changes in the underlying lung parenchyma.

0716 A CLASS OF NEW MICROWAVE THERAPEUTIC APPLICATORS. (Eng.) Lin, J. C. (Bioengineering Program, Univ. Illinois, Chicago, IL 60680); Fantor, G.; Ghods, A. Radio Science 17(5S):119S-121S; 1992 (11 refs).

A class of new direct-contact microwave (MW) applicators for hyperthermia and diathermia applications is described. The applicators consist of three concentric, circular, cylindrical tubes. The inner cylinder may serve as a port for circulating coolant to reduce surface temperature, as a port for introducing ionizing radiation in combination therapy for cancer, or to insert a temperature or field sensor for monitoring purposes. The coaxial waveguides formed by the inner and middle cylinders and by the middle and outer cylinders can be used to propagate TE_{11} and TE_{21} modes, respectively, for dual-beam, single frequency operation, or may be designed to permit two frequencies to propagate with the same TE_{11} mode. The dual-beam 2450 ± 50 -MHz applicator has an overall diameter of 10.4 cm at the output aperture. The annular regions formed by the middle and outer cylinders are loaded with high-density polyfoam to give added structural support. Dielectric loading may be used to maintain a small aperture diameter and still permit the propagation of TE_{11} and TE_{21} modes at lower frequencies. The applicator has a measured voltage standing wave ratio of 1.25. At the therapeutically effective specific absorption rate of 235 W/kg, the net forward power required is only 26 W; the maximum leakage at distances of 5 cm from the applicator surface in contact with a fat-muscle phantom is 4 mW/cm². These results compare favorably with the best designs available and are superior to the noncontact applicators currently in clinical usage. Thus the new applicator may be a good candidate for safe and efficacious use in diathermy and in hyperthermia for combination cancer therapy.

0717 IMPLANTABLE MICROWAVE RADIATORS FOR LOCAL HYPERTHERMIA. (Eng.) Samaras, G. M.; Samaras, G. M.; Cheung, A. Y.; Salazar, P. M. Radio Science 17(5S):121S-123S; 1992 (11 refs).

Microwave (MW) induced hyperthermia using internally located radiators promises a significant improvement in therapy for neoplasia in the esophagus, brain and other organs which are accessible through body orifices. Coaxial MW radiators should be able to pass through standard bronchoscopes and gastroscopes have been constructed, permitting direct visual control of radiator position. A needle radiator is combined with an antenna consisting of a linear array of half-wave dipoles which, instead of being connected by an external line that would interfere with the radiation pattern, are connected by an internal cable whose outer conductor is simultaneously used as the radiating element. The antenna is formed by cross-connecting the inner and the outer conductors of the cable at intervals, terminating in the needle antenna. When the radiator is placed in a phantom material with the same dielectric permittivity and loss tangent as human muscle at 2450 MHz, test results show more than 75% of the power at the radiator is absorbed by the phantom. In order to obtain realistic estimates of the temperature distributions induced by the coaxial radiators in live tissues, steady state in vivo heating patterns were measured in feline esophagus and brain. Both heating and cooling times were short. The MW radiation was confined to the target volumes with no detectable leakage.

0718 BIOLOGICAL AND BEHAVIORAL EFFECTS OF PRENATAL AND POSTNATAL EXPOSURE TO 2450-MHz ELECTROMAGNETIC RADIATION IN THE SQUIRREL MONKEY. (Eng.) Kaplan, J. (SRI International, Menlo Park, CA 94025); Polson, P.; Rebert, C.; Lunan, K.; et al. M. Radio Science 17(5S):135S-144S; 1992 (15 refs).

The effect of chronic microwave (MW) irradiation at or below the ANSI-recommended radiation protection guide for human exposure on prenatal and postnatal development of the squirrel monkey (*Saimiri sciureus*) was studied. Pregnant squirrel monkeys were exposed to 2450 MHz radiation in a split-mouth cavity at whole-body average specific absorption rates equivalent to those resulting from exposure to plane wave irradiation at 0, 0.034, 0.34, and 3.4 W/kg (8, 5, 6, and 4 monkeys, respectively). At births occurred, exposed animals were randomly assigned to groups for which exposures were either terminated or continued. In both cases, infants were treated together with their mothers for 6 mo, and then alone for an additional 6 mo. Births occurred 3 hr/day, 5 days/wk throughout the study. No differences were found between irradiated and

control adult monkeys with respect to the number of live births produced, or to measures of locomotor activity, maternal care, urinary catecholamines, plasma cortisol, phytohemagglutinin-stimulated response of peripheral blood lymphocytes, or electroencephalographic (EEG) activity. Offspring exposed at 3.4 W/kg both before and after birth had a high mortality rate (4/5) before 6 mo of postpartum age. These results suggest that MW radiation at power densities to 3.4 W/kg might have little direct effect on the monkey fetus when exposures occur in utero during the latter half to two-thirds of pregnancy but that continued exposure after birth may be harmful. No differences were found between exposed and nonexposed offspring in the same blood, urine, and EEG parameters; growth rate and most aspects of behavioral development were not altered by exposure. In a follow-up study, pregnancy outcome and offspring survival were compared between a group of 31 monkeys irradiated at 2450 MHz beginning in the first trimester of pregnancy and a group of 34 sham-treated controls. After parturition dams and their offspring were treated under the same conditions; then offspring were treated alone through 9 mo of age. The results of the latter study did not support those obtained in the initial experiment: no differences were found between irradiated and sham-exposed monkeys in the number of abortions, stillbirths, or livebirths that occurred or in the number of offspring that died.

0719 CONSTANT-DOSE MICROWAVE IRRADIATION OF INSECT PUPAE. (Eng.) Olsen, R. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). Radio Science 17(5S):145S-148S; 1982 (4 refs).

The effects of a constant total dose of 5.95 GHz microwave (MW) energy on pupae of the yellow mealworm *Tenebrio molitor* L. were investigated. Pupae were irradiated in the standing wave of a continuous MW beam. The standing wave configuration produced alternating planes of electric field (E) and magnetic field (H) intensities, and the pupae were mounted in either the E field or the H field plane. Exposure duration was 1.5, 3.0, 6.0, 12, or 24 hr with specific absorption rates (SAR) of 208, 104, 52, 26, and 13 W/kg, respectively. Irradiations were conducted both with and without a ventilating fan that limited the rise in chamber temperature to less than 4.5 C for all irradiations; without ventilation, the temperature increased about 11 C at the highest power level. Abnormal development as a result of the MW exposure was seen only in the high-power, short-duration experiment without chamber ventilation. It is proposed that a predominately thermal interaction mechanism operates in abnormal insect development, which hypothesis necessarily precludes the existence of cumulative effects. For this configuration and frequency, 40 C appears to be the threshold for effects.

0720 EFFECTS OF LOW-FREQUENCY ELECTROMAGNETIC FIELDS ON THE DEVELOPMENT OF THE CHICK EMBRYO. (Eng.) Aden, W. L. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). Radio Science 17(5S):149S-152S; 1982 (4 refs).

Studies of brain tissue susceptibility to low-frequency electromagnetic fields are reviewed. The results of experiments testing the possibility that the presence of lanthanum may modify the response of isolated chick brain exposed to weak oscillating electromagnetic fields are reported. Isolated chick cerebral hemispheres were incubated in pre-equilibrated solutions of different ionic content and then exposed to a 450 MHz field sinusoidally amplitude-modulated at 16 Hz to a depth of 50% at the power densities 0.75, 0.375, and 0.1875 mW/cm². The direction of efflux was vertically upward. The efflux of calcium was compared for solutions containing calcium carbonate, increased levels of calcium with calcium carbonate, without calcium, with phosphate buffer, and a solution containing lanthanum chloride. The left hemisphere was tested against the corresponding right brain with left and right sides serving as control and test samples. Efflux of calcium from the control solution was the control in the experiments. Increasing calcium concentration, pH, and ionic strength of solutions. Efflux in the lanthanum chloride solution served as reference in the experiments with lanthanum. The results of the experiments confirmed previous findings that radiofrequency fields amplitude-modulated at brain wave frequencies increase calcium efflux from isolated chick cerebral tissue. New observations include an absence of sensitivity of the response to variations of calcium concentration (0 to 4.16 mM) in the bathing solution, the enhancement by addition of hydrogen ions, and the inhibition in the absence of normal ionic concentrations. Addition of lanthanum to the bathing solution restored field sensitivity, and the lanthanum decreased calcium efflux. It is suggested that weak extracellular electric or magnetic fields acting at low frequencies or modulated at a low frequency modulation on a radiofrequency carrier wave may be transduced in a specific class of extracellular negative binding sites, normally occupied by calcium ions and susceptible to competition by lanthanum ion binding. The frequency and power windows so far defined for field interactions with extracellular calcium binding strongly suggest cooperative interaction based on long-range interactions in the length of a coherently organized charge system. The cooperative aspects of the interaction revealed in frequency and power windows may arise as a result of different role for hydrogen ions, with proton tunneling occurring between charges along the interface across the boundary between coherent and incoherent charge zones.

0721 COMPARISON OF MEASURED AND PREDICTED CHARACTERISTICS OF MICROWAVE-INDUCED SOUND. (Eng.) Lin, J. C. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508).

Current Literature

puter Engineering and Neurology, Wayne State Univ., Detroit, MI 48202); Meltzer, R. J.; Redding, F. K. *Radio Science* 17(5S):159S-163S; 1982 (16 refs).

The thermoelastic theory of microwave (MW) auditory effect was compared with new measurements obtained in cats and with previously available measurements. The theory describes the acoustic waves generated in the head as functions of the size of brain spheres, and characteristics of impinging and absorbed MW energies. Anesthetized cats were placed in a stereotaxic head holder using hollow ear bars. During the experiments, the animals' body temperature was maintained between 36 and 39 C. The dorsal aspect of the skull was exposed and insulated stainless steel electrodes were advanced to various brain stem nuclei and fixed to the skull. The reference gold pin electrode was always located near the lowest part of the right pinna. A small direct contact applicator (Flmed 15) was used to deliver short rectangular 2.5-25 usec-wide pulses produced by an Applied Microwave Lab. MW pulsed signal source (2450 MHz) at a rate of 10-100/sec. Peak incident power varied from 0 to 10 kW. Bioelectric activity extracted from the vertex and from each depth electrode was amplified by Grass (RM 122) amplifiers with a band pass of 80 Hz to 10 kHz and summated on-line using a Nuclear Chicago computer of average transient. The first 10 msec of the averaged response were displayed on the cathode-ray tube and also photographed. The thermoelastic theory correlated well with experimental measurements regarding the frequency of sound and threshold of sensation, width of impinging MW pulses, independence from MW frequency, and specific absorption rate distribution.

0722 THE EFFECT OF MICROWAVE RADIATION (1.0 GHz) ON THE BLOOD-BRAIN BARRIER IN DOGS. (Eng.) Chang, B. K. (Div. Hematology & Oncology, Dept. Medicine, Electrical Engineering & Neurosurgery, Duke Univ. Medical Center, Durham, NC 27710); Huang, A. T.; Joines, W. T.; Kramer, R. S. *Radio Science* 17(5S):165S-168S; 1982 (10 refs).

The integrity of the blood-brain barrier (BBB) was evaluated in dogs following exposure to continuous wave microwave (MW) radiation at 1.0-GHz (20 min at power densities ranging from 2 to 200 mW/cm²). The MW source was an AIL 125 generator. A Plexiglas apparatus for suspension of a double-ridged waveguide horn antenna was used to deliver near-field MW radiation directly onto the top of the head of anesthetized 15-20 kg mongrel dogs. Control (11) and exposed (21) dogs were injected with 25-30 uCi/kg of ¹³¹I albumin as a tracer. Cannulation of the cisterna magna and the femoral vein permitted simultaneous sampling of cerebrospinal fluid (CSF) and plasma every 20 min for 5 hr. Measurement of the CSF/plasma distribution ratio of ¹³¹I revealed no effect on the BBB at power densities of 2, 4, 10,

20, or 200 mW/cm². The BBB was intact in all cases.

However, 4/11 dogs exposed to 200 mW/cm² showed increased penetrance of the BBB by ¹³¹I albumin compared to controls (penetrance was 0.001 in 2 dogs, and 2-4% greater in the other 9). Two patterns were observed post-exposure: the CSF/plasma ratios in the exposed dogs rose with subsequent passage of time, and the standard deviation of controls was significantly lower to a level well outside the range of controls. A possible explanation for the results seen at 200 mW/cm² is that a MW with an average power density very near this value.

0723 EFFECTS OF HIGH-INTENSITY MICROWAVE EXPOSURE OF RAT BRAIN. (Eng.) Berman, J. (Bioelectromagnetics Res. Lab., Dept. Radiation Medicine, Univ. Washington, Seattle, WA 98195); Gray, C. F. *Radio Science* 17(5S):169S-178S; 1982 (11 refs).

The heads of female Wistar rats were exposed to 915-MHz microwave (MW) pulses of 100 msec (1 usec-360 msec) and power densities of 10-100 mW/cm². The threshold for the induction of unconsciousness. The exposure was terminated when the hindlimb withdrew with the threshold of unconsciousness. The threshold of unconsciousness corresponded to a constant value of 0.15 J/kg regardless of the pulse width or power density. Based on thermographic data, the threshold corresponded to a change in temperature of 0.5°C in brain temperature of 40.0°C (at the vertex of the skull) or a peak specific absorption rate of 0.15 W/kg. Rats exposed to pulses with a power density of 100 mW/cm² and pulse width of 100 msec, corresponding to energy levels of 10 J/kg, appeared to be normal after exposure. Rats exposed to pulses with energy above the threshold generally displayed petechial hemorrhages lasting for 1 min after exposure, followed by 1 min of unconsciousness. When exposed to energy levels corresponding to those on the threshold curve, the rats were stunned, but displayed a lethargic behavior. The period of unconsciousness increased with the amount of exposure energy above the old level. The temperature of the brain returned to the baseline level within 10 min. Rats began to move when the temperature of the brain was within 1 C of their normal temperature. A histological examination was performed on the brains of the rats: 1 control; 1 exposed to 100 mW/cm² pulses (below the threshold curve); 1 exposed to 10-kW, 0.1-sec pulses (well above the threshold level). Macroscopically, there was no difference among the 3 brains. However, electron microscopy indicated some dilatation of the endoplasmic reticulum and microfocal (0.1 usec) pulses of 10 kW at 100 msec and 100 mW/cm² at 100 msec indicated demyelination of neurons in the cerebral cortex 1 hr after exposure.

pathological findings in 2 exposed rats 1 mo after exposure were that the brains appeared swollen and microlocal glial nodules were present in the brain.

- 0224 INTERACTION OF AMBIENT TEMPERATURE AND MICROWAVE POWER DENSITY ON SCHEDULE-CONTROLLED BEHAVIOR IN THE RAT. (Eng.) Gage, M. I. (Neurotoxicology Div., MD-74B, Health Effects Res. Lab., EPA, Research Triangle Park, NC 27711); Guyer, W. M. Radio Science 17(5S):179S-184S; 1982 (15 refs).

The interactive effects of microwave (MW) power density and temperature on behavioral changes measured immediately after termination of exposure were investigated in 64 adult male Long-Evans rats trained to insert their heads into a food cup to obtain a 45 mg food pellet on a 1-min variable-interval schedule of reinforcement. Exposure to 2450 MHz continuous wave MW energy took place in an anechoic chamber under far field conditions; relative humidity was 50% during all exposures, and air velocity was 0.07 m³/sec. Two groups of 4 rats each were exposed for the 15.5 hr period from 1630 to 0800 hr under one of the following combinations of power density and air temperature: 8 or 14 mW/cm² at 22 C; 0, 8, or 14 mW/cm² at 26 C; or 14 mW/cm² at 30 C. Before MW exposure, 3 daily behavioral testing sessions followed a sham exposure at 22 C to acclimate the rats to the housing conditions during exposure. The last sham exposure also served as the 0 mW/cm² at 22 C exposure. The night following exposure, each group was given a sham exposure at the ambient temperature of the previous night. Rectal temperature was measured in 1 rat of each group before and after each MW or sham exposure. Behavioral testing occurred approximately 10 min after termination of exposure. MW irradiation was found to reduce rates of responding in direct proportion to the power density at each ambient temperature. This decrease of rate was most pronounced after exposures at 30 C. During sessions 1 day after MW exposure many rats showed behavioral overcompensation as response rates exceeded those measured the day before irradiation. When response duration was measured, increases in response duration were seen after exposures at 14 mW/cm² and 26 C and after exposure at both 8 and 14 mW/cm² when the temperature was 30 C. There were no significant increases in response duration after any exposures at 22 C. The results indicate that the intensity of MW irradiation and ambient temperature interact to increase decrements in rates of behavioral responding measured at the termination of irradiation.

- 0225 EFFECTS OF CONTINUOUS AND PULSED CHRONIC MICROWAVE EXPOSURE ON RABBITS. (Eng.) Chou, C.-K. (Bioelectromagnetics Res. Lab., Dept. Rehabilitation Medicine, Univ. Washington Sch. Medicine, Seattle, WA 98195); Guy, A. W.; McDougall, J.

A.; Han, L.-F. Radio Science 17(5S):185S-191S; 1982 (18 refs).

The effects of exposure to continuous wave (CW) and pulsed microwave (MW) fields for a 3-mo period were investigated and compared in 18 New Zealand rabbits (3 mo old; 9 male, 9 female). Animals were placed in Plexiglas cages and exposed singly in radiation anechoic chambers to CW, pulsed, or sham 2450-MHz plane wave fields for 2 hr/day, 5 days/week for 90 days. An S band standard-gain horn was located 1 m above the animal. Because of the limited power average power output (10 kW peak power) of the generator (Applied MW Lab. PH40K), maximum average power density at the animal location was 1.0 mW/cm². To maximize the animal exposure, rabbits were exposed singly to 1.5 mW/cm² pulsed fields (pulse width, 10 usec; repetition rate, 100 pulses/sec). The same average power density was used for CW exposure. Sagittal specific absorption rate (SAR) patterns were obtained thermographically; the sagittal SAR for 1.5-mW/cm² incident power density was 2.1 W/kg in a rabbit's back and 1.6 W/kg in the head region. Carbon loaded Teflon wires were used for the electroencephalogram (EEG) recording. A control for possible effect of circadian rhythms, the schedule of exposure for each group of rabbits was rotated. No significant differences were observed between the exposed and sham rabbits in body wt (measured every other day); EEG and evoked potentials (recorded 1/wk); blood tests (hematological, chemical, and morphological studies, 1/mo); or cataract examination before and after the 3-mo exposure. At the end of the 3-mo period, all 18 rabbits were injected with various dosages (1, 2, 4 mg/kg) of apomorphine to study drug induced hyperthermia and behavioral hyperactivity. However, 2 (1 exposed to CW, 3 pulse-exposed, and 1 sham-exposed) animals died during the experiment indicating that the animals were very sensitive to the apomorphine (normal young rabbits can tolerate up to 5 mg/kg dosage). The remaining rabbits (5 each exposed to CW or sham-exposed, 3 pulse-exposed) were sacrificed and detailed histopathological examinations were carried out. No consistent, significant differences in tissue damage were seen in the histopathological study.

- 0226 THE RESPONSE OF MOUSE MAMMARY TUMORS TO MICROWAVE HEATING AT 2450 MHz. (Eng.) Robinson, J. E. (Div. Radiation Therapy, Univ. Maryland Sch. Medicine, Baltimore, MD 21201); Alcorn, J. Y.; Harrison, G. W.; Samaras, J. Radio Science 17(5S):195S-199S; 1982 (8 refs).

The response of mammary carcinomas implanted in the flanks of female C3H mice to microwave-induced hyperthermia was studied and compared with water bath heating. Tumor regrowth time, time for the treated tumors to regress, and time for a vol twice that at the time of treatment were

as a criterion of tumor response to treatment. In order to minimize the size and shape dependence of the 1.48 GHz MW heating, the tumors were immersed in a slab of tissue equivalent bolus. Two types of bolus were used: a semisolid gel and a temperature controlled liquid bolus made up of 20% ethanol in isotonic saline. In order to reduce energy deposition gradients, two parallel opposed MW applicators dielectrically loaded to support a simulated transverse electromagnetic wave were energized alternately at a rate which was fast in comparison to that of tumor cooling. During heating in the gel, the temperature was monitored immediately adjacent to but not inside the tumor. Target temperatures were 42, 43, 43.5, and 44 C, together with an ambient temperature control. During heating in the liquid bolus, tumor temperatures were monitored for one of six animals per data point. Target temperatures were 42, 43, and 44 C; thermal controls were MW-heated to 37.5 C. The liquid bolus was kept at 1.0 C below target temperature for the tumors and sufficient MW power used to elevate tumor temperature to a level equal to or in excess of the target temperature. Data from tumors treated in the gel bolus yielded lower regrowth slopes and higher intercepts (greater regrowth times) than those of the control and the water bath-heated tumors. This may be due to nonuniform heating by MW energy with some small fraction of the tumor vol about 1 C below the target temperature. Regrowth curves that were consistent with homogeneous heating were obtained for tumors heated in liquid bolus. Slopes were steeper than for the semisolid bolus and there was little or no indication of the biphasic nature of the response curves seen after heating in the gel. A plot of thermal sensitivity vs. temperature suggested that all parts of the tumor were at or slightly above (0.4 C) target temperature. Thus, any difference in the effect of MW and water bath heating on the regrowth time of the tumors studied in this experiment was very small. Regrowth time of tumors with thermal probes left in place during the treatment was significantly greater than that of tumors in which no probe was present during MW irradiation.

0727 TREATMENT OF NON-UNION OF FRACTURES BY PULSED ELECTRO-MAGNETIC FIELDS. (Eng.) Hutchings, J. (Royal Hospital, Chesterfield, England). *Radiography* 48(566):25-32; 1982 (5 refs).

Results of treatment of non-uniting fractures with the ElectroBiology International Bi-Osteogen System unit are reported. The unit consists of a 250 V time-operated, quasi-square wave generator powering an O-shaped treatment coil and a plastic positioning block which is centered over the fracture site and attached to the external surface of a plaster of Paris cast moulded to the contours of the limb. The procedure for prescribing the system is outlined. Of 52 patients treated during the period 1976-1980, 38 fractures were proved to be radiographically and clinically united, representing a suc-

cess rate of 73.07%. The 14 failures were due to difficulty in immobilization with a minimum gap of 5 mm or more, and a case with a fixation screw in the gap, possibly causing and altering the induced field or the cell population in that area.

0728 MODEL FOR THE GROWTH OF BACTERIA UNDER ELECTROMAGNETIC RADIATION. (Eng.) Agabek, C. (Sect. d'Electromagnetisme & d'Hyperfréquences, Dept. Genie Electrique, Ecole Polytechnique, P.O. Box 6079, station "A", Montreal, Quebec, H3C 3A1, Canada); Bosio, R. G. *Speculations Sci Technol* 5(1): 15-22; 1982 (10 refs).

A multi-resonant interaction (MRI) model is proposed for the growth of cells in the presence of electromagnetic (EM) radiation. The cell growth cycle of *Escherichia coli* predicted by the MRI model is in good agreement with experimental data obtained since 1969 on the growth of *E. coli* subjected to EM radiation of variable frequency in the millimeter wave lengths. The MRI phenomenon is probably due to a difference in the dielectric properties of the cell colony and the adjacent medium. The hypothesis conceives that the retardation or stimulation of cellular growth is directly linked to the applied frequency of low power EM waves. An electro-mechanical resonance phenomenon may be the interacting agent which defines a given length of cellular colony at a given stage of development. According to the model, it should be possible to stimulate or retard cell growth by suitably programming the EM radiation periods regardless of the chosen operating frequency point.

0729 EFFECT OF MICROWAVE HEATING ON THE RADIATION RESPONSE OF RHABDOMYOSARCOMA. (Eng.) Zywiets, F. (Inst. Biophysics & Radiobiology, Univ. Hamburg, D-2000 Hamburg, W. Germany). *Strahlentherapie* 158(4):255-257; 1982 (12 refs).

The response of rat rhabdomyosarcoma R1H to single doses of X-rays (15 and 30 Gray) applied alone or in combination with hyperthermia (43 C) induced by 2450 MHz microwave (MW) radiation was investigated. Heat was delivered to the 2.3 cm³ tumors by a ring contact applicator 4.0 cm in diameter. MW heating of the tumors was performed 20 min after x-irradiation in 3 steps: (1) the tumors were heated for 10 min with the Radarmed 12T202 generator's maximum output power of 25 W, which led to a fast temperature rise; (2) the power was reduced to 1 W for 5 min; and (3) by applying 7 to 9 W, a constant tumor temperature of 43.0 ± 0.3 C was maintained. The temperature of the rat did not exceed 38.5 C during treatment. Heating the tumors at 43 C resulted in a growth delay that increased linearly with treatment time, up to 120 min. However, the animals survived

always tolerate 2-hr treatments. R1H tumors showed enhanced volume regression and tumor growth delay after combined treatment as compared to irradiation alone. After a single dose of 15 Gray, postirradiation hyperthermia treatments for 30 and 60 min led to thermal enhancement ratio (TER) values of 1.3 and 1.6, respectively. After a dose of 30 Gray combined with 30 or 60 min of hyperthermia, TER values were 1.5 and 1.7.

0730 MODELLING OF THE PERTURBATION INDUCED BY LOW-FREQUENCY ELECTROMAGNETIC FIELDS ON THE MEMBRANE RECEPTORS OF STIMULATED HUMAN LYMPHOCYTES (MEETING PAPER). (Eng.) Chiabrera, A. (Electrical Engineering Dept., Univ. Genoa, Viale Causa 13, I-161 45 Genoa, Italy); Grattarola, M.; Viviani, R.; Braccini, C. *Studia Biophysica* 90:77-78; 1982 (1 ref).

Lectins are known to induce the in vitro reactivation of human lymphocytes by acting as ligands of membrane receptors. Since most of the molecules involved are electrically charged, an effect on the parameters of the process due to electromagnetic (EM) perturbation can be anticipated. Two differential non-linear equations are proposed as a model of the interactions between receptors and lectins which give the time evolutions of the concentrations of couples of receptors (encounters) and complexes, respectively. Computer simulations of the time evolutions of receptors and complexes do not agree with experimental results and do not take into account the time spent by receptors together. Therefore, a gain function is introduced which is the ratio between the fraction of couples that, in the presence of lectins, remain together longer than a given time and the same expression in the absence of lectins. In principle, sinusoidal perturbations will always inhibit the process by lowering the value of the gain factor. This concept is in qualitative agreement with available experimental data.

0731 MOLECULAR BIOLOGICAL IMPLICATIONS OF ELECTRIC-FIELD EFFECTS (MEETING PAPER). (Eng.) Berg, H. (Central Inst. Microbiology and Experimental Therapy, Dept. Biophysical Chemistry, Acad. Sciences GDR, Beutenbergstrasse 11, DDR-6900 Jena, E. Germany) *Studia Biophysica* 90:169-176; 1982 (34 refs).

The interactions between biopolymers and biological membranes and electric fields produced by high single pulses with different electrodes or pulsed electromagnetic fields are reviewed. Single pulses can orient biopolymers and their complexes in solution, increase the permeability of membranes and disrupt cell walls, and fuse animal cells and protoplasts. In contrast to the single pulse technique, low pul-

sating fields require a longer time (up to 1000 sec) over a longer period (up to 100 min) to achieve the same logical and metabolic effects as single pulses. Other investigators and the author have used different fields. Normally, bursts of short duration (10-100 μ sec) and regular pulses (10-100 μ sec) are used. Short (about 1 μ sec) are used in biomembrane studies.

0732 ELECTRIC-FIELD-INDUCED CELL FUSION (MEETING PAPER). (Ger.) Arbeitsgruppe Membranphysik, Kernforschungsanlage, 5170 Jülich 1, W. Germany; Grattarola, M.; Viviani, R.; Braccini, C. *Studia Biophysica* 90:177-178; 1982 (1 ref).

The use of electric fields to induce cell fusion is described. Membrane contact between cells is achieved by dielectrophoresis in a nonuniform ac field resulting in the formation of pearl-chains. Suitable field strengths for the formation of pearl-chains are in the range 1-10 kV/cm. To initiate cell fusion, closer membrane contact has to be established by increasing the field strength for a very short time just prior to application of the breakdown pulse. The frequency range for dielectrophoretic collection should be between 10 kHz and 1 MHz. Reversible electrical breakdown in the zone of membrane contact is the primary process responsible for the initiation of fusion. Electrical breakdown is achieved by the application of a field pulse of short duration and of sufficient strength (0.5 to 7 kV/cm). Breakdown causes a few pores to be generated in the cell membranes so that a channel is formed between the two cells, through which mass transport can take place. Fusion is generally observed between cells within a pearl chain when a field pulse of 1 to 50 μ sec is applied and when the field strength is 1.5- to 10-fold higher than the critical field strength normally required for breakdown in the membrane sites. The technique can be used for the formation of pearl-chains.

0733 MODELLING OF THE PERTURBATION INDUCED BY LOW-FREQUENCY ELECTROMAGNETIC FIELDS ON THE MEMBRANE RECEPTORS OF STIMULATED HUMAN LYMPHOCYTES. I. INFLUENCE OF THE FIELDS ON THE SYSTEM'S FREE ENERGY. (Eng.) Grattarola, M. (Elettrotecnica, Univ. Genoa, Viale Causa 13, I-161 45 Genoa, Italy); Viviani, R.; Chiabrera, A. *Studia Biophysica* 90:171-174; 1982 (1 ref).

An attempt is made to model the experimentally demonstrated inhibitory effect of weak, low frequency electromagnetic (EM) fields on the in vitro reactivation of human lymphocytes. In vitro, lectin reactivated human lymphocytes form complexes with membrane receptors, glycoproteins, or more glycoproteins, and interact with the cell

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 REFERENCE TO SINGLE FBI FILE
 SINGLE EXPOSURE TO RUST MINE AREA
 THE REGIONAL OFFICE, NEW YORK
 (DATE: 1961-11-14) (TO: NEW YORK)
 (FROM: BUREAU) (SUBJECT: RUST MINE)
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A mathematical model is developed to describe the changes in the dielectric properties of the abdominal cavity during subcutaneous saline infusions and the single exposures to pulsed EM waves at 1.5 MHz (2800 MHz, 1.5 μ s pulse width, 100 W, 30 min). The complex dielectric properties of tissue samples was measured in the frequency range of a frequency of 1 GHz. An analysis of the data on the real and imaginary parts of the permittivity as a function of time after the MW exposure, the absorption of energy and the recession process of the saline in the meters is some kind of damped oscillation. Water content in the tissues and the volume of the abdominal cavity also follow the same

- 07-01 EFFECTS OF LOW-FREQUENCY
ON THE FETAL MEMBRANE AND
FETUS. (Invited) J. D. B. Jones,
Biophysics, NIDDK, 104-86, National
Park, NE 277-90; Durham, NC 27705.
tel no 252(331)1115 ext 124; fax 252(331)

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implantation exposure groups that were not affected by preimplantation exposure. The number of resorbed or resorbed fetuses was significantly increased in rats exposed on days 7 or 9. The effects appeared to be caused by RF-induced hyperthermia in the treated dams. A number of industrial, domestic, and medical devices operating at or near 2.45 GHz can cause hyperthermia in humans, and these results suggest that women of childbearing age should avoid exposure to RF-radiation levels that exceed current US occupational standards. It is also noted that maximum permissible exposure levels for pregnant workers in Czechoslovakia and West Germany are from 2 to 50 V/m, much below the AEC levels of 100-200 V/m.

0739 LOCAL MICROWAVE HYPERTHERMIA IN THE TREATMENT OF
THERAPY. PRELIMINARY REPORT. *Int. J. Radiat. Oncol. Biol. Phys.*
Valdagni, R. (Centro Oncologico, Inst. Ospedaliero, 38100 Trento, Italy); Amichetti, M.; Bellotti, G. *Tumori* 68(3):247-251; 1982 (23 refs.).

Microwave (MW) hyperthermia was used in combination with radiotherapy (15 patients) or chemotherapy (1 patient) to treat 19 histologically determined, superficially seated malignancies (11 squamous cell carcinoma, 4 melanoma, 1 adenocarcinoma, and 1 basaloma) refractory to other therapeutic measures. Of the 19 patients (5 females and 11 males; age range 42-65 yr, average age, 65 yr) 15 had a Karnofsky index ≥ 3 . Local MW hyperthermia to a preselected temperature (42.5, 43, 43.5, and 44 C) was applied 3 times for 20-55 min by a BSD-1000 computer-controlled hyperthermia unit operating at frequencies of 1.5-2.45 MHz. Thermometry was performed by implanted and surface probes placed on the skin and intratumorally inserted catheters. After radiotherapy (11 patients) hyperthermia (< 20 min), a complete response was observed in 9/18 treatment fields in 9 patients; a partial response $> 50\%$ in 5 and $< 50\%$ in 4. In 1 patient was not evaluable. Tumor regression objectively began about 2 wk after the first treatment. No tumor progression was observed during hyperthermia therapy or in mo 1 of follow-up. The only side effects directly attributable to hyperthermia were 1 skin burn in 147 treatment sessions. The 1 patient receiving chemotherapy 3 hr before and after hyperthermia exhibited no response.

Pulsed electromagnetic (EM) energy was applied to the calf of eight healthy 71-18-yr-old females.

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to investigate the effect of electrical stimulation on blood flow. An electronic device was constructed to deliver a train of pulses 200 μ sec wide in bursts every 5 msec with a repetition frequency of 10-15 Hz. Three separate signal generators were used to produce a composite signal which was magnified and fed into a set of coils wired in series. The induced field between the coils was 1.5-4.5 mV/cm. In four experiments, the coils were applied to the left thigh and right and left calf blood flow was measured by venous occlusion plethysmography. In a second series of four experiments, the coils were incorporated in a water-filled plethysmograph made of polycarbonate and the EM field was applied to the calf at the level at which blood flow was being measured. In all eight experiments, calf blood flow was recorded for a 3-min control period before the coils were switched on, then for 3-min periods when the coils had been on for 15, 20, and 27 min, and finally for 3 min after they were switched off. No significant difference was detected between right and left calf blood flow in either series of experiments. These findings suggest that the reported osteogenic effect of electrical stimulation on bone is not produced by variations in blood flow to the stimulated limb.

0741 ELECTROMAGNETIC AND ACOUSTIC PROPERTIES OF TISSUES. (Eng.) Burdette, E. C. (Biomedical Res. Div., Engineering Experiment Station, Georgia Inst. Technology, Atlanta, GA 30332). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:105-150; 1982 (87 refs).

In beneficial applications of electromagnetic (EM) and ultrasonic energy, an accurate knowledge of tissue dielectric and acoustic properties is essential. A brief discussion of the basic principles underlying EM and ultrasonic absorption and dispersion in tissues is presented, tissue property measurement techniques are reviewed, and results of dielectric and acoustic tissue property investigations are described. A brief description of in situ tissue property measurement techniques is given and in situ properties of living normal and tumor tissues are presented. Substantial differences have been found between the dielectric properties of tumors and normal host tissues. Accurate dielectric or acoustic property information that reflects in vivo characteristics is necessary for successful application of EM or ultrasonic diagnostic and treatment techniques in medicine and for accurately determining absorption in tissues. The capability for accurate in situ measurements of tissue dielectric and acoustic properties could be used in dosimetry determinations and in treatment planning for cancer patients using EM or ultrasonic-induced hyperthermia.

0742 PHYSICAL ASPECTS AND MECHANISMS OF NONINVASIVE THERMIA PRODUCTION BY ELECTROMAGNETIC AND MICROWAVES. (Eng.) Iskander, M. F. (Utah State, Salt Lake City, UT 84112). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:151-191, 1982 (22 refs).

The noninvasive production of hyperthermia for cancer therapy by electromagnetic (EM) techniques is described. The basic aspects of EM absorption in tissue are reviewed, with emphasis on the laws that describe the propagation of EM waves and the mechanisms involved in their interaction with materials such as tissue. The interaction of EM fields with tissue produces two basic types of effects which are reflected in the dielectric behavior, one related to the drift and oscillation of free charges and the other the polarization both through the alignment of the already existing electric dipoles or the production of new ones. The fundamental differences between heating mechanisms in short-wave (induction current type) and microwave (radiation type) diathermy are discussed. Examples of specific practical systems are used to illustrate the advantages and limitations of both procedures. Factors affecting the optimum frequency range for microwave diathermy are discussed. EM and ultrasound applications in hyperthermia are compared.

0743 POWER DEPOSITION WITH MICROWAVES. (Eng.) Paglione, R. W. (RCA Labs., Princeton, NJ 08540). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8:192-201; 1982 (10 refs).

A short review of the dielectric and thermal properties of tissues is presented. The success of hyperthermic treatment for cancer appears to be related to the ability to deliver uniform heat to specific volumes of tissues and to maintain the optimal temperature for the required period of time. The depth to which radiofrequency waves can penetrate into tissues and produce heating is primarily a function of the dielectric properties of the tissues and of the frequency. The designs and uses of waveguide, printed-circuit antenna, and coaxial applicators at microwave and radio frequencies are described and illustrated.

0744 CLINICAL HYPERTHERMIA WITH RF CATHETERS. (Eng.) Oleson, J. R. (Div. Radiation Oncology, Arizona Health Sciences Center, Tucson, AZ 85724); Cetas, T. C. In: Physical Aspects of

Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph M2280-3 6; 1982 (35 refs).

Mechanisms of interaction between radiofrequency (RF) radiation and biological tissue are reviewed briefly. RF fields are coupled to biological matter either in a capacitive mode in which RF current passes from one electrode to another through tissue interposed between electrodes, or in an inductive mode in which current flow results in tissue placed within an alternating RF magnetic field. Examples are presented illustrating each of these modes of RF heating as used for clinical hyperthermia. Phantoms are used to illustrate power deposition patterns in heterogeneous materials. Temperature distributions observed in clinical situations are qualitatively compared to these power density distributions. Work is in progress in the laboratory and clinical evaluation of newer techniques using magnetic induction. These include the following: 1) A coaxial pair of coils (Helmholtz pair) for heating by magnetic induction. Careful positioning of the coils is necessary to result in a maximum eddy current density passing through the tumor; 2) Ferromagnetic implants used in conjunction with the magnetic induction technique to preferentially absorb energy from an applied RF field. The tissue in the vicinity of the implant is heated by thermal conduction from the hot seed rather than by direct absorption of energy from the magnetic field; and 3) Curie point seed heating. These newer techniques may extend the usefulness of RF heating in clinical applications.

0745 CLINICAL APPLICATIONS OF HIGH FREQUENCY METHODS FOR LOCAL TUMOR HYPERTHERMIA. (Eng.) Corry, P. M. (Dept. Physics & Developmental Therapeutics, Univ. Texas System Cancer Center, Houston, TX 77030); Barlogie, B. In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8; 307-328; 1982 (10 refs).

Methods operating at frequencies in the high frequency (HF) spectrum (3-100 MHz) to induce local or regional temperature elevation in human tumors are reviewed. Criteria for an ideal system are presented and compared with methods that have been or can be used, including capacitive dielectric heating, magnetic induction heating, HF currents from implanted electrodes, ferromagnetic induction and hysteresis, as well as the use of phased annular arrays of radiators and folded dipole antennae driven at 433 MHz. Although there is no single method available which is ideal or which will facilitate hyperthermia induction in a wide range of tumor sizes, histologies, and anatomic locations, the work to date has provided guidelines for systems of

the future. The ability to deliver a dose of at least 45°C is essential for hyperthermia. Toxicity information indicates that the attention must be focused on the design of the interface to make the system safe. The observation of deep-seated pulmonary metastatic visceral lesions suggests that the energy is localized to the vicinity of the tumor.

0746 CLINICAL HYPERTHERMIA. (Eng.) Sandhu, T. S. (Univ. of Utah, Lake City, UT 84132). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8; 329-341; 1982 (61 refs).

Instrumentation required to treat cancer with microwave (MW) induced hyperthermia is reviewed. MW hyperthermia equipment includes a MW generator, circulator or isolator, power measuring devices, stub tuners, and MW applicators. Microwave applicators include the external waveguide, the slot, and intracavitary antenna types. Invasive methods include the use of intracavitary coaxial antenna applicators and phased array applicators. Static tissue equivalent phantoms for heating studies allow the selection of the type of applicator, the aperture size, and the MW frequency to be used to treat a prescribed target tissue volume. A dynamic phantom is described which can be used to study the effects of blood flow on the thermal field size produced by an applicator. The system is designed for use with noninvasive heat transducers and consists of a chamber divided into compartments, with liquid (e.g., saline) circulated to the top and bottom ones, and flow in the middle. The flow in this system is simulated by the direction, but the data obtained can be manipulated to account for counter current blood flow.

0747 MICROWAVE TECHNIQUES FOR CLINICAL HYPERTHERMIA. (Eng.) Chong, A. S. (Dept. Radiation Therapy, Univ. Maryland System, Baltimore, MD 21201). In: Physical Aspects of Hyperthermia. Nussbaum, G. H., ed. (American Inst. of Physics: New York); American Assoc. of Physicists in Medicine, Medical Physics Monograph 8; 343-351; 1982 (15 refs).

The rationale behind a systems engineering approach to microwave (MW) hyperthermia for cancer treatment and innovative engineering applications is leading to the implementation of clinical localized MW hyperthermia systems are described. A MW system for the induction of localized hyperthermia is divided into six subunits: induction, reheating, temperature measurement, power and temperature control,

the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is expected to increase to 1.7 billion by the year 2015. The number of illiterate people in the world is expected to increase to 1.7 billion by the year 2015.

[illegible]

- [illegible]

because of the problem of determining the measurement of electric magnetic fields in the scale phenomena, studies have been conducted. The mathematical field theory has been presented. Mathematical models have been developed to predict the effects of electric and magnetic fields on the human body. The models exposed to external fields, the internal fields and the possible effects on a two-dimensional field. The models of human subjects can be calculated by the procedure. This two-dimensional field is particularly useful for hyperthermia applications. It takes into account the spatial distribution of different tissues in the body and the field characteristics of the electromagnetic field.

- 4751 ANALYSIS OF THE EFFECTS OF SHORT-
DOSE-RATE EFFECTS OF THERMAL TREATMENT
HEAT, RADIATION AND HEAT TREATMENT
OF A PHASE III RADIOLOGICAL TREATMENT
ANIMALS. (Eng.) Jekel, M. J. In: *Thermal
Oncology*, Univ. Arizona Health Sciences Center,
Tucson, AZ 85724; Mon. 14 Oct 1984; 10 pp.
Final Aspects of Hyperthermia, Vol. 1, pp. 1-10.
(American Inst. of Phys. Sci. New York, 1984).
Soc. of Physicists in Medicine, 1984, 10 pp.

Bibliography: 8; 1953-1960; 1961-1962.

The results of a randomized Phase III trial to compare the relative efficacies of heat alone, radiation alone, and radiation plus heat to treat tumors in pets are reported. A total of 77 dogs and cats with a variety of spontaneous malignancies were stratified by tumor type and randomized to receive therapy. The heat prescription was 44 ± 2 C for 30 min 1/wk, while the radiation dose was 460 rad/fraction 2/wk for 8 fractions. When the treatments were combined, heat preceded one radiation treatment each week by no more than 10 min. All but 3 of the heated patients were treated with 500-kHz radio-frequency current using parallel plates, needles, or a plate plus needles; 3 patients with superficial tumors received 2450 MHz microwaves. A comparison of overall response rates showed that the fraction of patients with no response was significantly higher for heat alone than with either of the other two treatment arms. The complete response rates for heat alone and radiation alone were significantly lower than that for heat plus radiation. Analysis of potential therapeutic gain factors based on moist desquamation as a normal tissue endpoint indicates that larger values are possible for large tumors ($> 10^3$ cm³) than for small ones. In the heat plus radiation group, response rates and durations were dependent on minimum temperature monitored in the tumor. Temperature measurements should be made during each treatment, since predictable heating patterns were not seen except in a few cases. In patients treated with heat alone, there was no correlation between minimum heat dose and prognosis.

0752 BIOELECTROCHEMISTRY - ELECTROPHYSIOLOGY - ELECTROBIOLOGY. (Eng.) Findl, E. (Bio Research, Inc., 315 Smith St., Farmingdale, NY 11735). In: Modern Aspects of Electrochemistry, Bockris, J. O., Conway, B.E., White, R.E. eds. (Plenum Publishing Co: New York) Vol 14:509-555; 1982 (127 refs).

A review is presented of interactions between electric fields and biological matter, with emphasis on transmembrane potentials, bioelectrokinetic phenomena, and surface charges of biomaterials. Topics discussed include electric fields and ion transport, cellular transmembrane potentials, potentials that are generated in vivo by motion between biofluids and cellular materials in the cardiovascular system, and potentials generated in bone and cartilage. The author presents results from in vivo and in vitro experiments to support the hypothesis that electrocardiogram waveforms are largely due to electrokinetic potentials. Medical and biological applications include the use of electric fields to stimulate bone growth and limb regeneration, and electric currents to induce electroanesthesia and to relieve chronic pain and eliminate pain during surgical procedures (e.g., in dentistry, gynecology, surgery, neurology, and psychiatry). The surface charge and surface energy of a material have been shown to affect the ability of the material to absorb blood

components and to be critical to the action of electric currents or electric fields. Electric fields are also used to facilitate passage of substances across the blood-brain barrier, to influence cell growth and cellular differentiation, to induce membrane breakdown, and to promote wound healing.

0753 RISK/BENEFIT ANALYSIS OF MICROWAVE RADIATION CASE. (Eng.) Steneck, N. (University of California, San Francisco Press: San Francisco, CA) 1982 (174 refs).

A conference sponsored and supported by the Michigan Collegiate Inst. for Research in Science and the National Science Foundation, and the National Science Foundation, was held in 1981 was the basis of this volume. The problem of setting safety standards for radiofrequency (RF) and microwave (MW) radiation through risk/benefit analysis is the central theme of the papers in the volume. The volume covers the origins and present state of the MW debate; the identification of critical cost/benefit issues; the effects of RF and MW energy on biological systems; safety practices in the USSR and some other countries; results of an inquiry by the National Communications Commission on potential health effects of radiation; the costs of perceived adverse effects of MW radiation; a suggested use for the results of analysis in the MW debate; cost, risk, and benefit of the military; the importance of the public and environment; cost/benefit analysis, risk/benefit analysis in the formulation of protective standards; nonionizing electromagnetic standards and their implementation; the effect of extraneous factors on MW research; science, objectivity, and the MW debate. While individually, the papers in this volume provide no simple, correct resolution to the MW debate, as a group, they cover the major issues of view that must be considered seriously in decision making, if consensus is to be achieved. Areas of agreement and disagreement among the contributors and participants are summarized in an appendix.

0754 MICROWAVE AND RADIOFREQUENCY RADIATION. (Eng.) Michaelson, S. M. (Dept. Radiol. Biology and Biophysics, Sch. Medicine & Dentistry, Univ. Rochester, Rochester, NY). In: Nonionizing Radiation Protection. Suess, M. J., ed. (WHO Regional Office for Europe, Copenhagen, Denmark; WHO Regional Publications, European Series No. 40) 1982 (174 refs).

The frequency ranges considered are 3-300 MHz for radio frequency radiant energy, and 300 MHz-300 GHz for microwaves (MW). An attempt has been made to delineate areas of uncertainty with respect to biological effects and gaps in the state of knowledge. The review covers physical, chemical,

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Biological Effects of Nonionizing Radiation VIII: *Hyperthermia*

General principles; biological effects and health aspects; instrumentation and measurement; MW/RF sources and devices; protection measures and techniques; protection guides and standards; and health monitoring. It is recommended that the development of new and additional sources of MW/RF exposure be carefully followed and monitored. Consistent efforts should be made to minimize the impact of these sources on man and the environment. Continued attention should be given to the development of dosimetry and to the standardization of measurement techniques; greater attention should be given to the investigation of fundamental interactions of MW/RF energy with biological systems.

0755 ELECTRIC AND MAGNETIC FIELDS AT POWER FREQUENCIES, WITH PARTICULAR REFERENCE TO 50 AND 60 Hz. (Eng.) Hauf, R. (Res. Inst. Electrophysiology, Freiburg, W. Germany). In: Nonionizing Radiation Protection. Suess, M. J., ed. (WHO, Regional Office for Europe, Copenhagen, Denmark); WHO Regional Publications, European Series No. 10; 1982; 193 (68 refs).

Electric (E) and magnetic (H) fields are generated by power transmission systems and wherever electric energy is used, whether in domestic activities, in transportation, or in industry. Future power transmission network voltages are expected to exceed the present level of 800 kV, and a transmission voltage of 1.2 MV is projected for the near future. In the interest of health protection, the effects that the E and H fields may have on man are reviewed. It is concluded that many observed phenomena, particularly changes in behavior, attributed to the effects of E and H fields can easily be explained by secondary effects which are not field-specific. Experimental studies show that E fields of intensity up to 20 kV/m and H fields of intensity up to 240 A/m, whether individually or in combination, do not constitute a danger to health. Epidemiological studies of exposure to E fields in workers in high-voltage substations and on power lines have failed to show any adverse health effects. No mechanism of action is known whereby power frequency fields can produce direct effects on living organisms, and no specific symptoms have been detected in humans as a consequence of exposure to these fields. E and H fields caused by transmission systems up to 420 kV are not considered to constitute a danger to human health; it can be assumed that this is also true for 800 kV systems.

0756 MEDICAL APPLICATIONS OF RADIOFREQUENCY-RADIATION HYPERTHERMIA (FINAL REPORT JANUARY 82). (Eng.) Kiel, J. L. (USAF/SAM, Brooks AFB, TX). Report No. SAM-TR-82-38, Oct 82. Contract No. 3357; 41. [available through NTIS, Springfield, VA 22161, Document No. PB82-116913]; 72 p.; 1982.

field, VA 22161, Document No. PB82-116913; 72 p.; 1982.

This report provides an overview of the potential applications of radiofrequency radiation to hyperthermia. RFR has limitations in its ability to penetrate but can heat tissue selectively, depending on its water content and dielectric properties. Nonionizing electromagnetic radiation can produce effects through several mechanisms, which are dependent on the amount of energy deposited, the dose rate, and the type of tissue irradiated. These attributes provide great versatility in the utilization of RFR. Furthermore, the synergism of RFR with ionizing radiation and chemotherapy, as treatment increases their effectiveness at lower doses. Lowered toxicity is a direct consequence of a lower effective dose in the presence of RFR. With improved therapeutic instrumentation, dosimetry and a better understanding of the mechanisms, the number of medical applications and the effectiveness of RFR should continue to increase.

0757 EFFECTS OF 200, 500 AND 700 MHz MICROWAVE WAVES ON CEREBRAL ENERGY METABOLISM. (Eng.) Sanders, A. P. (Duke Univ. Medical Center, Durham, NC); Joines, W. T. Sponsored by Health Effects Research Lab., Research Triangle Park, NC. Report No. EPA-600/182-014, Oct 82. Prepared in cooperation with Duke Univ., Durham, NC Dept. of Electrical Engineering. Contract No. EPA-600/182-014. [available through NTIS, Springfield, VA, Document No. PB83-116913]; 72 p.; 1982.

Previous work has shown that levels of key biochemicals in the energy production system of rat brain are affected by exposure to 591 MHz microwave radiation at 13.8 mW/cm². The objectives of this study were to determine whether there are direct microwave effects on the biological system or whether they are secondary to the hyperthermia produced in the tissue, to establish dose-response relationships for the effects, and to investigate different frequencies of exposure and modulation of the carrier signal. The fluorescence of reduced nicotinamide adenine dinucleotide (NADH) in the rat brain was measured *in vivo* during exposure to the microwave radiation, and adenosine triphosphate (ATP) and creatine phosphate (CP) levels were measured chemically after exposure.

0758 MICROWAVE TESTING ON MICE YIELDS QUALITATIVE EFFECTS (NTIS TECH NOTE). (Eng.) Dept. of the Navy (Washington, DC). While NTIS has information about Tech Notes subscriptions and back issue packages available. [available through NTIS, Springfield, VA 22161, Document No. PB82-116913]; 72 p.; 1982.

This citation summarizes a one-page announcement of technology available for utilization. A single, 15-minute exposure to 2450-MHz microwave radiation is sufficient to reach a threshold that stimulates a significant increase in mouse splenic B lymphocytes bearing cell surface receptors for the third component of complement, according to recent tests. They also showed that the effect of absorption of multiple subthreshold quantities of energy was cumulative, provided the exposures occurred within 1 hr of each other. For additional information, contact: Navy Technology Transfer Fact Sheet, Code F411, Naval Surface Weapons Center, Dahlgren, VA 22448; report No. 70504/TN.

0754 HYPERTHERMIA IN RHESUS MONKEYS EXPOSED TO A FREQUENCY (225 MHz) NEAR WHOLE-BODY RESONANCE. (Eng.) Lotz, W. G. (Naval Aerospace Medical Res. Lab., Pensacola, FL 32508). Report No. NAMRL-1284, 1 Jun 82. Contract No. F58524; MF5852-4020. [Available through NTIS, Springfield, VA 22161, Document No. AD-A118 364]:13 p.; 1982.

Exposure of Rhesus monkeys to 225 MHz radiation caused severe hyperthermia at power densities $> 5 \text{ mW/cm}^2$ (2.3 W/kg). A comparison of body temperature responses to exposure at two frequencies, 225 and 1290 MHz, indicated that the resonant frequency (225 MHz) is at least 2-x more effective in causing hyperthermia than the higher frequency, even after considerations of specific absorption rate (SAR) are included in the analysis. It was concluded therefore, that the effects on Rhesus monkeys of exposure to a resonant frequency (225 MHz) were substantially greater than what could be predicted based upon straightforward comparisons of dosimetric information (SAR) and the effects of exposures to a much higher frequency (1290 MHz).

0760 BIOLOGICAL EFFECTS OF STATIC MAGNETIC FIELDS: A SELECTIVE REVIEW WITH EMPHASIS ON RISK ASSESSMENT. (Eng.) Easterly, C. E. (Oak Ridge Natl. Lab., TN). Contract No. W-7405-ENG-26. [Available through NTIS, Springfield, VA 22161, Document No. PB82-013350]:78 p.; 1982.

Rather than focusing on literature per se, the current study determines the status of magnetic field information that is applicable to risk assessment. Hence, an attempt is made to identify both the literature that is useful to the goal of risk assessment and a framework within which risk assessment methodologies can be derived. From this selected review, it is concluded that three areas exist for which adequate information can be found to begin modelling: disease induction, reproduction and development, and cardiovascular response. The first two are supported by a combination of positive and

negative findings and the last by only positive findings. A technique which utilizes the physical principle of flow retardation for measuring the velocity of fluid moving through a magnetic field.

0761 MECHANISM OF ELECTROMAGNETIC INTERACTIONS OF THE NERVOUS SYSTEM. (English). TAL SYSTEM AND PRELIMINARY RESULTS). (Eng.) Jumbell, N. L. (Naval Ocean Systems Center, San Diego, CA 92152); Brandt, C. L. Report No. NOSC-TR-82-1, July 82. Contract No. ZR00001; 61. [Available through NTIS, Springfield, VA 22161, Document No. AD-A117 527]:68 p.; 1982.

Effects of high-level electromagnetic (EM) energy on living nerve tissue were assessed by subjecting individual nerve cells of the marine gastropod *Aplysia californica* to microwave radiation levels of 10-300 mW/cm². Of the 84 exposed cells, 7 showed inhibitory responses and 1 showed excitatory response that required 6-82 min to develop. In each case, the cell returned to normal activity within 70 min of removing the EM field. It is concluded from the data collected that interaction of EM energy with the electrical activity of nerve cells does exist, and that this interaction is not heat-related. Understanding the mechanism of this interaction will provide a valuable tool in determining the hazards of nonionizing EM energy and the associated safety limits of exposure.

0762 ANNUAL REPORT, DIVISION OF BIOLOGICAL EFFECTS, BUREAU OF RADIATION HEALTH (FISCAL YEAR 1980). (Eng.) Bureau of Radiation Health (FDA, Rockville, MD). Report No. BRS-PUB, BRS-PUB, Mar 82. [Available through NTIS, Springfield, VA 22161, Document No. PB82-013350]:1982.

The Division of Biological Effects, Bureau of Radiation Health, plans, conducts, and reports on epidemiological and experimental studies of the biological effects of both ionizing and nonionizing radiation, including x-rays, radiopharmaceuticals, ultraviolet light and ultrasonic, electromagnetic al and extramural epidemiological studies, laboratory investigations, and animal studies. From the literature, the division evaluates research to assess the health effects of ionizing and nonionizing radiation. This report gives an overview of the work completed and in progress for the period October 1979 through 30 September 1980. It supports the related radiation research and evaluation, particularly as it concerns the biological effects of exposure to electronic products.

Current Literature

Biological Effects of Nonionizing Electromagnetic Radiation on Man, Fish, and Birds

0763 INTERACTIONS OF RADIOFREQUENCY RADIATION WITH NITELLA: ELECTRICAL EXCITATION AND PERTURBATION OF THE CONTROL OF CYTOPLASMIC STREAMING (MASTER'S THESIS). (Eng.) Wong, L. S. (Air Force Inst. Technology, Wright-Patterson AFB, OH). Report No. AFIT-NR, Mar 82. [available through NTIS, Springfield, VA 22161, Document No. AD-A116 213];94 p.; 1982.

Radiofrequency radiation (RFR) of 0.5 Hz - 2.5 GHz at field strengths on the order of 10 V/cm has been shown to interact with isolated *Nitella* internodal cells in two separate and frequency dependent manners. At frequencies up to approximately 10 KHz, RFR acts to directly excite the cell membrane, eliciting an action potential and halting cytoplasmic streaming. There is no reason to believe the RF induced action potentials and accompanying streaming cessations occur through a mechanism different from that which results from conventionally applied excitatory stimuli. Microscopic observations of the streaming in cells exposed to RFR gave no evidence of direct action by RFR upon the mechanism which generates the motive force. Streaming alterations, however, did indirectly indicate the existence of a field induced disruption of the calcium ion release which normally occurs upon membrane excitation. On the basis of these observations and previously reported theoretical models of RF interactions with biological systems, a molecular mechanism for the electrically mediated release of calcium ion is presented.

0764 OPEN-ENDED COAXIAL EXPOSURE DEVICES (PATENT APPLICATION). (Eng.) Burdette, E. C. (Dept. of the Air Force, Washington, DC). Report No. PAT-APPL-6-357 442; filed Mar 82. [available through NTIS, Springfield, VA 22161, Document No. AD-D009 487];24 p.; 1982.

A device for, and a method of, delivering a known amount (i.e., a dose) of electromagnetic energy radiation in the radiofrequency/microwave frequency range to a specimen of organic material (e.g., a cell and/or a tissue culture), and thereby exposing the specimen to the delivered energy. The device comprises a source of the desired electromagnetic energy to which is electrically connected a coaxial cable having an open end which terminates in a centrally located aperture of a circular brass ground plane plate to which, in turn, is electrically and mechanically connected to a metallic ring which is positioned such that it is equidistant from the aperture in which the energy-radiating open end of the coaxial cable is located. A circular culture dish which is positioned over the aperture, within the metallic ring, and on the ground plane plate holds the specimen of organic material which is exposed to the energy radiated from the open end of the coaxial cable.

0765 REVIEW OF HEALTH AND SAFETY ASPECTS OF VIDEO DISPLAY TERMINALS. (Final Report). (Eng.) Gagnon, W. C. (Communications and Control, Ottawa, Ont., Canada). Sponsored by NADA, Washington, DC. Report No. CRC-TN-712-1, Feb 82. [available through NTIS, Springfield, VA 22161, Document No. AD-A116 214];39 p.; 1982.

The factors that contribute to worker complaints when video display terminals (VDT) are introduced into the workplace are investigated. Data from field experiments indicate that a number of ergonomic factors and job characteristics contribute to reports of discomfort from VDT use. Specifically, reports of visual discomfort are related to improper ambient lighting (which causes bothersome reflections and contrast glare), display quality, and opthamological defects. Reports of muscle pain and fatigue are related to poor work-station design such as improper height of chair, keyboard, and display screen, and absence of source document holder, and no support for the forearms and wrists. It is noted that the frequency of such complaints is influenced by the worker's attitude regarding the job. A negative attitude arising from performing a meaningless, unchallenging task, or from having no opportunities for career advancement, will result in more complaints about ergonomic shortcomings. The issue of electromagnetic emissions from television displays is also considered.

0766 MECHANISMS OF MICROWAVE NEURAL INTERACTION (FINAL REPORT). (Eng.) Davis, J. L. (Dept. Biology, Utah Univ., Salt Lake City, UT 84112); Burney, C. H. Contract No. N00014-80C932. [available through NTIS, Springfield, VA 22161, Document No. AD-A116 215];21 p.; 1982.

Examination of the binding characteristics of an acetylcholine receptor (AChR) and either tritium-labeled acetylcholine ($^3\text{H-ACh}$) or calcium (^{45}Ca) via a modified Hill plot revealed a synergistic binding for both acetylcholine (ACh) and calcium (Ca^{++}) in low concentrations. In the presence of a specific inhibitor of AChR, a decrease was observed at a specific binding site (SAR) of $1.5 - 2.0 \text{ mW/cm}^2$ (SAR). When a continuous wave of 1.8 mW/cm 2 was applied, SAR was 0.64 in both cases). Cooperative binding of Ca^{++} was not changed at physiological concentrations (0.25). Experiments performed at 0.25 mW/cm 2 distinguished from those at 1.8 mW/cm 2 .

0767 MICROWAVE INTERACTIONS WITH ACH RECEPTORS IN THE CENTRAL NERVOUS SYSTEM. (Final Report). A PARADIGM OF NEURAL INTERACTION. (Eng.) Olsen, E. G. (Naval Air Force Medical Research Development, Ft. Belvoir, Ill.). Sponsored by NADA, Washington, DC.

81. Contract No. MR04108; MR0410801. [available through NTIS, Springfield, VA 22161, Document No. AD-A118 821]:15 p.; 1982.

Microwave-induced developmental effects in insects have been studied at several laboratories during the past decade. Results of the initial experiments were interpreted to show a so-called nonthermal microwave effect, but as more studies were conducted by various investigators, a predominantly thermal effect appeared to be the best explanation. This report presents the results of a comprehensive series of insect irradiation experiments including a rigorous statistical analysis of the data. Statistical analysis shows no microwave-induced effects for exposure of up to 4 hr at dose rates of 63 W/kg. Irradiation at higher intensities (102-126 W/kg) did produce statistically significant effects when applied over a 2-4 hr period.

0768 THE EFFECT OF PULSED MICROWAVES ON THE BREATHING OF MICE. (Swe.) Criborn, C. O. (Forsvarets Forskningsanstalt, Stockholm, Sweden); Henriksson, C. I.; Clemedson, C. J. Sponsored by NASA, Washington, DC. Report No. FOA-C-54032-H2 H3, Apr 81. [available through NTIS, Springfield, VA 22161, Document No. N82-22873]:20 p.; 1981.

With the use of a specially constructed microwave generator, mice were exposed to microwaves synchronized to the different stages of respiration. Frequencies other than the respiratory rate affect the volume and rate of respiration in shorter intervals of exposure. Even though the animals were not heated at the low average effect, approximately 1 mW/cm² during exposure, a change in body wt was measurable. These results indicate that the thermal energy balance in mice is somehow affected.

0769 DOSIMETRIC AND BEHAVIORAL ANALYSIS OF MICROWAVE-DRUG SYNERGISTIC EFFECTS ON OPERANT BEHAVIOR IN THE RAT. (FINAL REPT. Sep 79-Dec 81). (Eng.) Lovely, R. H. (Battelle Memorial Inst., Pacific Northwest Lab., Richland, WA); Lundstrom, D. L.; Phillips, R. D. Contract No. N00014-79-C-0819. [available through NTIS, Springfield, VA 22161, Document No. AD-A115 115]:26 p.; 1981.

Five male Long-Evans rats maintained at 80% of their free-feeding wt, were trained to bar press for food reward on a 1-min fixed-interval (FI) schedule of reinforcement. Once stable FI baseline response rates were established dose-response functions were generated for Chlordiazepoxide HCl (CDZ). Subsequent treatments with CDZ were followed by 30 min pulsed microwave radiation (MWR) and FI behavioral

assessment. Pulsed MWR exposure was conducted in the zone of an anechoic chamber at an averaged incident power density of 1 mW/cm² (PRF=30/sec, pulse width=100 µsec). After 2 replications of the combined treatments another CDZ dose-response function was generated. This was followed by 3 more CDZ dose-response functions the first of which was carried out at an averaged incident power density of 1 mW/cm². Increased rates of response for the CDZ and MWR treatment were demonstrated relative to control. CDZ dose-response functions in 4 of 5 rats tested. However, the dose-response functions for CDZ alone that were generated following this apparent synergy showed the same shift in response rate. Further, 8 mW/cm² pulsed MWR combined with CDZ also produced data similar to the 1 mW/cm² post-MWR exposure. Dose-response functions for the animals tested. Thus, an earlier demonstration of synergy between CDZ and MWR could not be replicated.

0770 SUBTLE CONSEQUENCES OF EXPOSURE TO WEAK MICROWAVE FIELDS: ARE THERE NON-THERMAL EFFECTS. (Eng.) Lovely, R. H. (Biology and Physics Res. Lab., Univ. Hosp., Seattle, WA 98195); Mizumori, S. J. Y.; Johnson, R. B.; Guy, A. W. Prepared in cooperation with Battelle Pacific Northwest Labs., Richland, WA, Biology Dept., and California Univ., Berkeley, Dept. of Psychology. Contract No. N00014-75-C-0464. [available through NTIS, Springfield, VA 22161, Report No. AD-A116 933]:53 p.; 1983.

When we speak of subtle consequences of exposure we mean only that the effects were observed in the absence of changes in core temperature due to microwave exposure. When we measure the difference in core temperature consequent to microwave exposure, we are witnessing a breakdown of thermoregulatory mechanisms. Short of this event, the exposed subject makes a number of thermoregulatory and metabolic accommodations to maintain a constant body temperature and to deal effectively with the energy being deposited in its tissues. These latter changes should interest us for they are the subtle consequences of exposure to weak microwave fields. The long-term accommodations, which accompany chronic exposure, can lead to a number of interesting effects some of which are described below. Two fundamentally different types of experimental protocol were employed. In Experiment IA, independent groups of male rats were either exposed or sham-exposed to 915 MHz microwaves for 10 hr bright light for 2 to 4 mo. In Experiment IB, independent groups of rats were similarly exposed, or sham-exposed, to 2450-MHz microwaves for 10 hr bright light for 2 to 4 mo. In Experiment II, using a different type of protocol, pregnant female rats were exposed for 2 hr bright light 19 days of gestation. Control groups were either sham-exposed or served as caged controls. The main focus of the study attended to assessment of dose-response functions and the developmental status of the parent rats' progeny.

tenacity being determined from the test of the evaluation values of water in a plastic container. In the control rats the body temperature was 36.2-36.4°C higher than the control group, heat or microwave radiation. No change was observed in the brain, compared with the control group, was observed. Anesthetized and unanesthetized animals showed an acceleration of the heart rate as the body temperature increased. At microwave intensities over 30 mW/cm² the rate temperature rose.

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The Division of Biological Effects, with the National Risk Assessment Panel, conducted a number of major epidemiologic and experimental research projects on biological effects of exposure to electromagnetic radiation, magnetic fields, and electric currents with the following emphasis: (1) epidemiologic studies, (2) laboratory studies, and (3) risk assessment. The report of our activities for several programs during Fiscal Year 1981, Division Internal and extramural epidemiologic studies, and laboratory investigations, and critical review of the literature, the Division Studies and Laboratory Health Effects is resulting from exposure to radiation, and studies and develops techniques for the assessment of energy distribution in biological tissues in order to provide quantitative dose-effect information. The responsibility for risk assessment and the development of scientifically-based biological criteria in support of exposure standards, performance standards, and voluntary guidelines for the reduction of emission and radiation levels are being primarily within the Division.

12-00000 POTENTIAL HUMAN MUTAGENICITY OF A
NON-IONIZING RADIOFREQUENCY ELECTROMAGNETIC
FIELD EFFECTS. (English) New York: American
Radiation, Inc., Melrose, MA. 1984. 10 pp. 10 refs.
by Health Effects Research Lab., USA. For sale by
Annie Park, MD. Report No. HES-84-00000. \$10.00.
84, 10000000. No. USA. 84-00000. 10 pp. 10 refs.
through NIOS, Springfield, MA. 1984. 10 pp. 10 refs.
PES-84-00000. 1984.

It is important to recognize that the impact of the environment on the health of the population is not only a function of the health status of the population, but also a function of the health status of the environment. The health of the environment is a function of the health of the population, and the health of the population is a function of the health of the environment.

[illegible]

ous occupations and applications of radio frequency radiation (RFR) were identified and evaluated for their suitability for further study. Many populations were eliminated early to avoid their potential exposure to RFR was too limited or data necessary for epidemiological research were unavailable. Eight populations were evaluated in detail and appear to satisfy many of the criteria for epidemiological research and could be useful study groups in an investigation of the health effects of non-ionizing radiation. The eight potential study populations are: RF heat sealer operators, high frequency tube welder operators, medical diathermy operators in Veterans Administration hospitals, medical diathermy operators in rehabilitation facilities, school children located near broadcasting towers, state policemen, security guards, and radar technicians.

0716 EFFECTS OF ELECTROMAGNETIC RADIATION ON CALCIUM IN THE BRAIN (TECHNICAL REPORT). (Eng.) Greengard, P. (Southeastern Center for Electrical Engineering Education, Inc., St. Cloud, FL); Douglas, W. W.; Nairn, A. C.; Nestler, E. J.; Ritchie, J. M. Prepared in cooperation with Yale Univ. New Haven, CT, Dept. of Pharmacology. Report No. SAM-REVIEW-2-82, Jul 82. Contract No. F33615-78-D-0017; 7757; 01. [available through NTIS, Springfield, VA 22161, Document No. AD-B066 822/3]:117 p.; 1982.

Electromagnetic radiation has been reported to alter several aspects of nervous system function. Authors have claimed effects of radiation on calcium efflux from nervous tissue, on thermoregulation, on the blood-brain barrier, and on several other aspects of brain function, including behavioral, electrophysiological, and neurochemical processes. In most cases, either the results of these studies cannot be confirmed by other investigators or the biological significance of the results is unclear. Most (but not all) investigators accept that radiation alters the efflux of calcium from nervous tissue. But even accepting the validity of these findings, one is left with little indication as to what the results mean for the functioning of the central nervous system. Despite the plethora of studies that demonstrate radiation effects on the blood-brain barrier, the available evidence, together, indicates that permeability of the barrier remains intact except when the exposure involves very high power densities which produce thermal damage.

0717 PRELIMINARY STUDY OF THE BIOLOGICAL AND BIOLOGICAL EFFECTS OF HIGH INTENSITY OF H₂ ELECTRIC FIELDS (INTERIM TECHNICAL REPORT). (Eng.) Greengard, P.; Douglas, W. W.; Nairn, A. C.; Nestler, E. J.; Ritchie, J. M. Prepared in cooperation with Yale Univ. New Haven, CT, Dept. of Pharmacology. Report No. SAM-REVIEW-2-82, Jul 82. Contract No. F33615-78-D-0017; 7757; 01. [available through NTIS, Springfield, VA 22161, Document No. AD-B066 822/3]:117 p.; 1982.

Smith, M. D.; Gurney, R. J. (1983) Biological effects of electromagnetic radiation. In: *Biological Effects of Electromagnetic Radiation*, Ed. by P. Greengard, pp. 1-10. (Contract No. AG1-111111, Contract No. AG1-111111, Springfield, VA 22161, Document No. AD-B066 822/3):117 p.; 1982.

Increasingly higher voltages for power transmission lines are currently being used. The increased efficiency of such lines, coupled with increases in the cost of energy, will make ultra-high voltage lines a necessity. The serious question arises of what effects the high intensity electric fields will have on living organisms. The objective of the preliminary study (Phase I) is to develop and thoroughly test the apparatus and experimental protocols which are required for a major study (Phase II) which will determine the effects of such fields on living organisms. The experiments in Phase I were not intended to produce scientifically valid results. The results should be considered as anecdotal but potentially useful in forming hypotheses. In Phase I a group of six individual subjects and a group of four social subjects were placed in the exposure facility. An initial pre-exposure period allowed data to be gathered for 14 experimental days before any electric fields were turned on. A similar (post-exposure) period followed the exposure period. For the first experimental group, the exposure period was a 6-wk period during which data were gathered on 23 days. The exposures of subjects in the preliminary study were to 30 kV/m of electric fields.

0718 EFFECTS OF MAGNETIC FIELD EXPOSURE ON FERTILIZATION SUCCESS OF RAINBOW TROUT, *Salmo gairdneri* (CONFERENCE PROCEEDING). Strand, J. A. (Battelle Pacific Northwest Labs., Richland, WA); Abumethy, G. S.; Spalding, J. E.; Genoway, R. G. Sponsored by Dept. Energy, Washington, DC. Report No. PNL-SA-942, Conference, Jul 81. Contract No. AC06-80OR1800. [available through NTIS, Springfield, VA 22161, Document No. DES14 0111119 p.; 1981.

Initial studies conducted at this laboratory (Strand et al., 1980) suggested that fertility of trout eggs could be affected by magnetic fields of 1 Tesla. Additional studies were planned to confirm these results and to examine the relative susceptibility of egg and sperm to magnetic fields. Preliminary results and their interpretation are presented. For additional information see *PNL Report, Volume 11, Number 1, Abstract No. 11-1111*.

0719 BIOLOGICAL EFFECTS OF HIGH INTENSITY OF H₂ ELECTRIC FIELDS (INTERIM TECHNICAL REPORT). (Eng.) Greengard, P.; Douglas, W. W.; Nairn, A. C.; Nestler, E. J.; Ritchie, J. M. Prepared in cooperation with Yale Univ. New Haven, CT, Dept. of Pharmacology. Report No. SAM-REVIEW-2-82, Jul 82. Contract No. F33615-78-D-0017; 7757; 01. [available through NTIS, Springfield, VA 22161, Document No. AD-B066 822/3]:117 p.; 1982.

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Research conducted during the contracting period has involved a continuation of an investigation of the in vivo effects of exposure of Dutch rabbits to electromagnetic pulsed (EMP) fields and an in vitro study of the effects of transient electrical and electromagnetic fields on biomembranes. Phenomenological studies of the effects of EMP exposure of Dutch rabbits have been undertaken in an attempt to characterize the nature of the alterations induced by such fields, whereas the biomembrane studies have been directed toward a mechanistic understanding of field-induced alterations in biological model systems.

0783 INVESTIGATION OF THE BIOLOGICAL EFFECTS OF PULSED ELECTRICAL FIELDS (ANNUAL PROGRESS REPT. NO. 2, 1 Feb 76 - 30 Jan 77). (Eng.) Cleary, S. F. (Dept. Biophysics, Virginia Commonwealth Univ., Richmond, VA 23298); Hoffman, R.; Liu, L. Contract No. N00014-75-C-0334. [available through NTIS, Springfield, VA 22161, Document No. AD-A091 813/6]:74p.; 1977.

The investigation of the effects of pulsed electrical fields on mammalian erythrocytes indicates that such fields produce transient pores or channels in the cell membrane as evidenced by the release of intercellular potassium ions and hemoglobin (and perhaps other intracellular protein molecules). The release has been found to be strongly dependent upon the duration of the electric field pulse as well as the amplitude of the electric field. Significant intracellular potassium release occurs under exposure conditions that do not result in release of protein molecules, suggesting that the size of the induced pore is dependent upon the induced field strength and the duration of the field. The mechanism of dielectric breakdown of cell membranes does not adequately account for these results. The results of studies of the relationship of field strength and pulse duration for the rupture of an artificial bilayer lipid membrane (oxidized cholesterol) indicate a dependency on the pulse duration that is consistent with the effects upon cell membrane permeability. The in vivo studies have involved the exposure to Dutch rabbits to repetitively pulsed electromagnetic fields in an EMP simulator. Such exposure has not been found to result in significant alterations in a number of physiological response variables including the duration of drug induced sleeping time and serum chemistry changes, although there is some suggestion (nonstatistically significant) of a post-exposure increase in certain serum enzymes.

0784 THE EFFECTS OF CORDIAMINE AND MESATONE ON THE ECG DURING ACUTE MICROWAVE IRRADIATION. (Rus.) Koldaev, V. M. (Medical Institute, Novosibirsk, USSR). Farm Toksikol 47:111-114; 1982 (12 refs).

The protective effects of analeptic and atropinic drugs during acute microwave (MW; 1.16 m wavelength) irradiation were studied in randomly bred albino mice. The animals were subjected to a 10 min MW exposure at 37.2 J/cm² (for 10 min), 47.2 J/cm² (for 12 min), or 75 J/cm² (for 20 min). Immediately after irradiation, the animals received a subcutaneous injection of cordiamine (25, 50, 100, or 150 mg/kg) or mesatone (5, 10, 25, 50 or 100 mg/kg). The animals were followed up for 3 wk. The optimal doses of cordiamine and mesatone that provided a 100% increase in the survival of MW-irradiated mice were 100 and 10 mg/kg, respectively. MW irradiation produced a transient dose-dependent increase in rectal temperature and decrease in pulse rate of the mice. ECG examination showed marked elongation of the P and PQ segments in mice irradiated at 55.8 and 75 J/cm². Administration of the drugs enhanced the normalization of the ECG changes induced by MW radiation.

0785 WEATHER RADARS AS A SOURCE OF SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS AND THE PROBLEMS OF ENVIRONMENTAL HYGIENE. (Rus.) Kozlovskii, Iu. D. (A. N. Marzhev Res. Inst. Institute of Community Hygiene, A. I. Voeikov Chief Geophysical Observatory, Central Aerological Observatory, USSR); Nikitina, N. G.; Tomashevskaya, L. A.; Pavlov, F. R.; Zhupakhin, K. S.; Iurmanov, V. V. Gig Sanit (2):7-11; 1982 (7 refs).

To evaluate the potential environmental and health hazards of weather radar generating superhigh frequency (SHF) electromagnetic fields (wave length of 0.8, 3, 10 and 17 cm, power flux density of 1-4,000 uW/cm²), random-bred albino rats were subjected to chronic 4-mo exposure to SHF fields of 115, 60, 40, 25, 10, and 5 uW/cm². Biological effects were estimated by behavior reactions, physical endurance, biochemical and immunological parameters. Exposure to SHF fields at 115 and 60 uW/cm² resulted in a 1.5- to 1.1-fold increase in the threshold of galvanic skin response and a 10% decrease in physical endurance. At power densities of 40 and 25 uW/cm², the animals showed changes in the reflex latency. Exposure to SHF fields at 115 and 60 uW/cm² caused inhibition of cholinesterase activity, increase in serum plasmin activity, a significant increase in urea and nitrogen levels, and a decrease in glycogen levels. SHF fields at 40 and 25 uW/cm² resulted in the increase in adrenaline levels in the brain and in the adrenal glands.

Current Literature

- 0787 HYGIENIC EVALUATION OF 8-mm ELECTROMAGNETIC FIELDS. (Rus.) Dumanskii, I. D. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR); Tomashevskaya, L. A. Gig Sanit (6):1-2; 1982 (4 refs).

The potential health hazards of 8-mm electromagnetic fields generated by weather radars were studied in albino rats. Daily exposures to EM fields were carried out at power densities (PD) of 140, 100 and 60 $\mu\text{W}/\text{cm}^2$ (12 hr/day for 4 mo). The biochemical effects of exposure were estimated by blood urea and residual nitrogen concentration, liver glycogen levels, blood cholinesterase activity, serum ceruloplasmin and transferrin concentrations, and succinate dehydrogenase and cytochrome oxidase activity in liver and brain mitochondria. Exposure to PDs of 140 and 100 $\mu\text{W}/\text{cm}^2$ caused an increase in blood urea levels, inhibition of succinate dehydrogenase and cytochrome oxidase in liver mitochondria, and inhibition of blood cholinesterase. Exposure to a PD of 140 $\mu\text{W}/\text{cm}^2$ increased the residual blood nitrogen level, decreased the liver glycogen level, and increased ceruloplasmin activity. The most marked changes in biochemical parameters were observed after exposure to 140 and 100 $\mu\text{W}/\text{cm}^2$ fields for 3 and 4 mo. Exposure to the 60 $\mu\text{W}/\text{cm}^2$ field failed to induce any changes in rat metabolism.

- 0788 HYGIENIC EVALUATION OF THE BIOLOGICAL EFFECTS OF NONIONIZING MICROWAVE RADIATION. (Rus.) Belekrintskii, V. S. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR). Gig Sanit (6):32-34; 1982 (7 refs).

The results of studies on the biological effects of centimeter-band electromagnetic (EM) radiation are summarized. A Luch-58 generator (wavelength, 12.6 cm) was used to irradiate experimental animals in an anechoic shielded chamber, at power densities ranging from 1-5 $\mu\text{W}/\text{cm}^2$ to 500 mW/cm^2 . Rats exposed to low power density EM radiation (1-50 $\mu\text{W}/\text{cm}^2$) exhibited a mild increase in succinate dehydrogenase and glucose-6-phosphate dehydrogenase activity. Chronic exposure to EM radiation at 10, 25, and 50 $\mu\text{W}/\text{cm}^2$ (3 hr/day for 2 mo) resulted in dose-dependent changes in the ultrastructure of brain cells. Single exposure to EM radiation at 500 $\mu\text{W}/\text{cm}^2$ caused damage of mitochondria, endoplasmic reticulum, cell nuclei and nucleoli; the structural damage was associated with an increase in enzyme activity and enhanced synthesis of glycogen, DNA, and RNA. Single exposure of cats and dogs to EM radiation at 10 or 400-500 mW/cm^2 resulted in marked dilatation of blood arterioles, enlargement of intercellular space, marked decrease in collagen level, demyelination and vacuolization of nerve fibers, and changes in the size and shape of various cells. These findings indicate that histochemical and ultrastructural parameters are highly sensitive to EM radiation and that changes in these parameters can be used in

to evaluate potential genetic hazards of microwave (MW) radiation of nonthermal intensities, male random-bred albino rats were irradiated with MW generated by a Luch-58 apparatus (2,375 MHz) at power flux densities (PFD) of 10 $\mu\text{W}/\text{cm}^2$ (7 hr/day for 45 days), 50 $\mu\text{W}/\text{cm}^2$ (7 hr/day for 45 days), and 500 $\mu\text{W}/\text{cm}^2$ (single 7 hr exposure). One day after termination of exposures at 10 $\mu\text{W}/\text{cm}^2$, the animals were subjected to x-irradiation (12.9 mCi/kg). On day 7 after MW and x-irradiations, the rats underwent partial hepatectomy, and the liver specimens were subjected to cytogenetic analysis. A single exposure to MW at PFD of 500 $\mu\text{W}/\text{cm}^2$ did not increase the number of cells with chromosome aberrations (16.4%, compared with 17.2% in controls). The incidence of chromosome aberrations in rats subjected to chronic MW irradiation at 10 $\mu\text{W}/\text{cm}^2$ was 1% lower than that in the controls (2.15 and 1.64%, respectively). Preliminary exposure to MW at 10 $\mu\text{W}/\text{cm}^2$ reduced the incidence of chromosome aberrations induced by x-rays. The rats subjected to chronic exposure at a PFD of 50 $\mu\text{W}/\text{cm}^2$ showed a bimodal distribution of chromosome aberrations.

hygienic estimation of maximum permissible levels of exposure to microwave radiation.

- 0789 INCIDENCE OF DIGESTIVE SYSTEM DISEASES IN WORKERS EXPOSED TO LEAD IN COMBINATION WITH SHF ELECTROMAGNETIC FIELDS. (Ukr.) Titus, M. S. (Res. Inst. Industrial Hygiene & Occupational Diseases, Ukrainian SSR Ministry Public Health, Kiev, USSR). Gig Sanit (9):93-94; 1982 (4 refs).

The health hazards of combined exposure to lead and superhigh frequency (SHF) electromagnetic fields were studied in workers in the electronics industry. Analysis of the incidence of digestive system disorders in workers exposed to lead vapors alone or in combination with SHF fields (dosages within or slightly greater than maximum permissible exposure levels) showed frequent food intolerance, loss of appetite, and epigastric pain. The incidence of chronic gastritis, chronic cholecystitis, stomach ulcer, and duodenal ulcer in workers exposed to lead vapors alone was significantly greater than that in workers exposed to SHF fields alone or in combination with lead vapors. The characteristic feature of exposure to SHF fields alone was hyperacid gastric secretion, compared with hypacidity after exposure to lead vapors alone.

- 0790 GENETIC HAZARDS OF MICROWAVES OF NON-THERMAL INTENSITY AND THEIR HYGIENIC ASPECTS. (Rus.) Shandala, M. G. (A. N. Marzeev Res. Inst. General and Community Hygiene, Kiev, USSR); Antipenko, E. N.; Koveshnikova, I. V.; Timchenko, O. I. Gig Sanit (10):38-41; 1982 (17 refs).

To evaluate potential genetic hazards of microwave (MW) radiation of nonthermal intensities, male random-bred albino rats were irradiated with MW generated by a Luch-58 apparatus (2,375 MHz) at power flux densities (PFD) of 10 $\mu\text{W}/\text{cm}^2$ (7 hr/day for 45 days), 50 $\mu\text{W}/\text{cm}^2$ (7 hr/day for 45 days), and 500 $\mu\text{W}/\text{cm}^2$ (single 7 hr exposure). One day after termination of exposures at 10 $\mu\text{W}/\text{cm}^2$, the animals were subjected to x-irradiation (12.9 mCi/kg). On day 7 after MW and x-irradiations, the rats underwent partial hepatectomy, and the liver specimens were subjected to cytogenetic analysis. A single exposure to MW at PFD of 500 $\mu\text{W}/\text{cm}^2$ did not increase the number of cells with chromosome aberrations (16.4%, compared with 17.2% in controls). The incidence of chromosome aberrations in rats subjected to chronic MW irradiation at 10 $\mu\text{W}/\text{cm}^2$ was 1% lower than that in the controls (2.15 and 1.64%, respectively). Preliminary exposure to MW at 10 $\mu\text{W}/\text{cm}^2$ reduced the incidence of chromosome aberrations induced by x-rays. The rats subjected to chronic exposure at a PFD of 50 $\mu\text{W}/\text{cm}^2$ showed a bimodal distribution of chromosome aberrations.

[illegible]

1. What is the purpose of the study?
 The purpose of the study is to determine the effect of the use of a computer program on the learning of the English language.

- Bioelectrical effects of short-term exposure to a 5-Hz frequency 1-mA intensity electromagnetic field (EMF) were studied in adult and 10 male rabbits. The animals were irradiated with sine-modulated EMF generated by the WPK-3m apparatus for a field intensity of 1, 2, 2.5-5.0 V/m, 3-50 pulses, and a total duration of exposure of 15-12 min. The effects of EMF were estimated by the changes in electrical activity of the cerebral cortex and by changes in heart rate. Electroencephalography (EEG) showed that adult rabbits assumed the 5-Hz modulation rhythm of EMF; the effect was less pronounced for a 1-2-Hz modulation. In contrast with adult rabbits, the EEG biopotentials in old animals did not assume the EMF modulation rhythm. Electrocardiographic (ECG) analysis showed that 1-hr exposure to 5-8-Hz EMF at intensities of 2.5-5.0 V/m resulted in a mild decrease in the heart rate. Exposure of old rabbits to 8-Hz EMF at 2.5-5.0 V/m induced extrasystoles.

0797 ANALYSIS OF FREQUENCY RELATIONS OF LOGI-
CAL LOGICAL EFFECTIVENESS OF A MAGNETIC FIELD
IN A RANGE OF MICROPELLETTATION OF A GEOMETRIC FIELD
(0.01-100 Hz). (Rus.) Makeev, V. E. (no affiliation
given); Temurliants, N. A. Probl. Écos. Biol.
43:116-128; 1982. (2 refs.).

- To evaluate biological activity of short-period oscillations of a geomagnetic field, random-bred rats were exposed to an alternating magnetic field (AMF) generated by a NGPK-3m apparatus (intensity of 5, 100, 5) and 5:1 gamma, rectangular or sine-modulated pulsed with duty factor of 0.5). Biological effects of AMF were estimated by blood cell count and the functional characteristics of peripheral blood neutrophils. The biological activity of AMF depended upon its frequency and type of modulation. Exposure to AMF at 0.02 Hz resulted a marked increase in peroxidase, alkaline phosphatase, and cationic protein concentrations, an increase in the phagocytic index, and an increase in serum gammaglobulin levels indicative of enhanced nonspecific resistance. Exposure to AMF at 5 Hz was associated with a decrease in all histochemical indices, a decrease in the phagocyte index, and a decrease in blood complement and lysozyme levels. Exposure to AMF at 0.5 Hz resulted in an increase in peroxidase activity in peripheral blood neutrophils and a concomitant decrease in cationic proteins and alkaline phosphatase levels. Opposite effects on the indices of nonspecific resistance were also observed after exposure to AMF at 9-10 Hz. The biological activity of rectangularly-modulated AMF was more pronounced

Health hazards of radio-frequency electromagnetic fields (RF EMF) were studied in 82 workers (60.25% women, average age 35.1 yr) at an international telephone exchange. The workers were exposed to amplitude modulated or pulsed EMF with frequencies of 4 KHz to 12 MHz; the average intensities of the electric and magnetic components at the workplace were 1.5-7.7 V/m and 0.5 A/m, respectively. The maximum intensities were 29.6 V/m for the electric component and 5 A/m for the magnetic component. The workers who had an occupational exposure to RF EMF showed elevated blood pressure, headache, fatigue, irritability, hyperesthesia, neurasthenia, menstruation disorders, inhibition of neutrophil phagocytosis, a decrease in the erythrocyte count, and a decrease in serum albumin concentrations.

tion that of sine-modulated AMF.

0795 BIOLOGICAL EFFECTIVENESS OF WEAK INFRALOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Temur'iants, N. A. (no affiliation given). Probl Kosm Biol 43:128-139; 1982 (20 refs).

Biological effects of infralow-frequency weak electromagnetic fields (EMF) were studied in young (3-mo old) and adult rabbits, in 3-wk-old puppies, and in adult dogs. The animals were exposed to 8-Hz EMF with intensities of 1, 0.1, and 0.01 V/m for a single 3-hr exposure, or for 1x for 3 hr/day, every 3 days. Intensities of EMF corresponded to the intensity of the geomagnetic field during the period of high solar activity. The biological activity of EMF was estimated by changes in the functional state of peripheral blood neutrophils. Single exposures to EMF resulted in an increase in neutrophil size, a marked decrease in the activities of oxidases and alkaline phosphatase, and a mild decrease in glycogen levels. Analysis of the effects of chronic exposure showed two-phase changes in the cytochemical indices: a marked decrease in enzyme activities and glycogen levels after the first 3 irradiations, followed by progressive normalization of the cytochemical indices during the last 4 exposures. Puppies and young rabbits were more sensitive to EMF exposure than adult dogs and rabbits. The decrease in enzyme activity and glycogen level was more pronounced in rabbits than in dogs.

0799 PATHOLOGICAL CHARACTERISTICS OF EXPERIMENTAL MYOCARDIAL INFARCTION AFTER EXPOSURE TO LOW-FREQUENCY LOW-INTENSITY ELECTROMAGNETIC FIELDS. (Rus.) Artishchenko, V. A. (no affiliation given); Vinogradov, S. A.; Volynskii, A. M.; Perederii, V. G. Probl Kosm Biol 43:139-147; 1982 (14 refs).

The effects of low-frequency low-intensity electromagnetic fields (EMF) on pathogenesis, clinical manifestations, and healing of myocardial infarctions were studied in rabbits and guinea pigs. Myocardial infarction was induced by ligation of the left coronary artery. The animals were subjected to whole-body continuous irradiation with EMF (8 Hz, 0.8 V/m) generated by the NCPK-3m apparatus. Within 2-10 days after exposure, the animals were sacrificed, and myocardium specimens were examined histologically and histochemically. Exposure of animals with myocardial infarction to EMF resulted in more pronounced hyperemia of the perivascular and interstitial connective tissue, development of dystrophic processes in the myocardium tissue adjacent to the infarction zone, and development of fresh microcirculation foci.

0800 REACTIONS OF A BIOLOGICAL SYSTEM TO ADEQUATE WEAK LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Kislovskii, L. Ia. (no affiliation given). Probl Kosm Biol 43:141-147; 1982 (10 refs).

The mechanisms of response of a biological system to weak low-frequency electromagnetic fields (EMF) are discussed. A characteristic feature of any complex biological system is a non-linear or phase response to a stimulus. Specific effects of weak magnetic and electric fields are associated with changes in the spatial orientation of atoms and a decrease in orientation entropy of various chemical reactions. Weak magnetic fields have a specific effect on an excited unstable system if their intensity does not exceed a certain critical value. Cooperative effects provide for significant elongation of the duration of the excited state. Weak stimuli affect cluster structures of water, and the formation of metastable structures. These structural changes create the conditions conducive to kinetic isolation of a calcium ion with several water molecules for a time sufficient for the rearrangement of electron orbits.

0801 EFFECT OF MAGNETIC FIELDS ON RADIOSENSITIVITY OF MICE. I. EFFECT OF INFRALOW-FREQUENCY LOW-INTENSITY MAGNETIC FIELDS ON SURVIVAL OF ANIMALS SUBJECTED TO WHOLE-BODY X-IRRADIATION. (Rus.) Kopylov, A. N. (Life Science Faculty, M. V. Frunze State Univ., Simferopol, USSR); Trutskii, M. A. Radiobiologiya 22(5):647-660; 1982 (6 refs).

The modifying effect of low-frequency magnetic fields was studied in random-bred male mice subjected to whole-body x-irradiation (56 rad/min, total dose of 750 rad). Before or after irradiation, the animals were exposed to an alternating magnetic field (AMF) at frequencies of 0.1 and 8 Hz, and intensities of 4.06 and 10.06 A/m for 3 hr. A 30-day survival rate in the animals subjected to x-ray irradiation alone was 34.8%. Exposure to AMF had a significant effect on the survival of irradiated mice. Preirradiation exposure to 0.1-Hz AMF had a radioprotective effect at both intensities (57.3% and 69.4% respectively), while 8-Hz AMF had a radioprotective effect only at 4.06 A/m (51.8%), compared with 36.0% at 10.06 A/m. Postirradiation exposure to AMF failed to provide a statistically significant effect.

0802 USE OF MATHEMATICAL MODELS FOR ANALYSIS OF ADAPTATION PROCESSES IN PERIPHERAL BLOOD. (Rus.) Antonov, M. Ia. (N. N. Medvedev Res. Inst. General and Community Hygiene, Kiev, USSR); Gonchar, N. M. Radiobiologiya 22(5):841-849; 1982 (9 refs).

The first case of infection in a child was reported in 1964, when a 10-month-old girl in California had a severe illness with fever, vomiting, diarrhea, and convulsions. The child died 10 days later. The illness was caused by a virus isolated from the child's stool. This virus was identified as the same virus that had been isolated from the stool of a child in California in 1963. The virus was named "rotavirus" because of its characteristic wheel-like shape when viewed under an electron microscope. Rotavirus is a common cause of severe diarrhea and vomiting in young children. Most children who are infected with rotavirus recover completely within a few days. However, in some cases, the infection can lead to dehydration and even death. The virus is spread through contact with infected stool or vomit, or through contaminated surfaces. Rotavirus is also spread by direct contact with an infected person. The virus is very hardy and can survive on surfaces for several days. There is no specific treatment for rotavirus infection. The best way to prevent infection is to practice good hygiene, including frequent hand washing with soap and water. Rotavirus vaccines are available for infants and young children. These vaccines can help prevent severe illness and death. The Centers for Disease Control and Prevention (CDC) recommends that all infants be vaccinated against rotavirus. The vaccine is given in two doses, one at 12 weeks of age and another at 15 weeks of age. The vaccine is safe and effective. It has been shown to reduce the risk of severe rotavirus infection and hospitalization. The vaccine is also effective in preventing death. Rotavirus is a common cause of illness in young children. It is important to recognize the signs and symptoms of infection and to seek medical attention if your child has severe diarrhea or vomiting. Rotavirus vaccines are available and can help prevent severe illness and death. It is important to keep your child up to date on their rotavirus vaccinations.

OKR 5. EVALUATION OF THE TREATMENT OF CHRONIC
 PERICARDITIS WITH ELECTROMAGNETIC WAVES.
 THE TREATMENT OF PATIENTS WITH STOMACH AND INFLAM-
 MATION. (Preliminary report). V. M. Zverev, Inst.
 Bathology and Physical Therapy, Moscow, USSR.
 Vasilov, E. V., Frolov, I. N., Koles, I. N.,
 Ponomarev, I. I., Shcheglov, I. N., Zverev, V. M.,
 Tr. Arkh. 5 (1948-1949), 1962 (in russ.).

The therapeutic efficacy of irradiation of the thyroid gland with decimeter-band waves (DBW) was studied in 110 patients (70-85 yr old) with stomach or duodenal ulcers. DBW were generated by a "Korona-mashka" apparatus (460 MHz, wave length 1.25 m, power flux density of 120 mW/cm², 6 min/day, for a total of 15-20 irradiations per course). Complete healing of the ulcer was observed in 71.8% of the patients, compared with 48.6% after a conventional therapy. Remissions of 71 and 1.5% were observed in 71.5% and 4.0% of the patients, respectively. DBW irradiations stimulated secretion of thyroglobulin and thyroid hormones, reduced gastric juice secretion, reduced gastric acidity, increased blood lysozyme and complement levels, decreased titers of circulating antibodies against stomach and duodenal tissues, and improved gastric motility. These findings indicated that the therapeutic effect of DBW in patients with stomach and duodenal ulcers is associated with stimulation of the endocrine system.

0896 BIOLOGICAL AND MAGNETIC EFFECTS OF ULTRA-
SHORT-LENGTH LASER RADIATION ON THE ACTIVITY
AND NEUROPHYSIOLOGY OF THE CENTRAL NERVOUS
SYSTEM. A. A. Kozlov, L. A. Kozlova, V. A. Kozlov,
M. A. Kozlov, M. A. Kozlov, USSR Acad. Sci., Moscow,
USSR, *Dokl. Akad. Nauk SSSR*, 1983, 271, 1-3, 1-3.

Current literature data on the biological effects of magnetic fields (MF) and on methods of recording biomagnetic fields are reviewed. The physical parameters of MF dependence, its induction, frequency,

pulse type, vector, gradient, localization, and duration of exposure. The sensitivity of an organism to MF is associated with its age, sex, and individual characteristics. Response to MF is characterized by a prolonged latent period; changes in the biological parameters of MF produce insignificant changes in response latency. Both slow and fast systems of initial sensory response were observed after exposure to superhigh frequency electromagnetic fields. The initial response to MF is followed by an overall rearrangement reaction and an adaptation reaction. An adaptation response which involved the endocrine system was observed after daily exposures of > 20 min in duration. MF-induced adaptation reactions were associated with changes in erythropoiesis, redox potentials, and cell membrane permeability. Therapeutic applications of MF are associated with increased resistance to infection, temperature exposure, and ionizing radiation. Prolonged exposure to MF induced various pathological changes. The biophysical mechanisms of MF activity can be described by changes in sodium-potassium gradient, orientation of RNA and DNA macromolecules, and polarization of the side-chains of protein molecules.

0807 AUTOALLERGIC EFFECTS OF EXPOSURE OF RATS TO SUPERHIGH FREQUENCY ELECTROMAGNETIC FIELDS AND THEIR ACTION ON THE FETUS AND OFFSPRING. (Rus.) Shandala, M. G. (A. N. Marzeev Res. Inst. General & Community Hygiene, Kiev, USSR); Vinogradov, G. I. *Vestn Akad Med Nauk SSSR* (10):13-16; 1982 (11 refs).

The role of immunological factors in the mechanism of hazardous effects of superhigh frequency (SHF) electromagnetic fields (EMF) was studied in pregnant Wistar rats. The animals were exposed to SHF EMF generated by a Luch-2 apparatus (500 uW/cm²) for 7 hr/day during the entire 20-day gestation period. To evaluate the effect of autoantibodies on embryogenesis, pregnant intact rats were immunized with serum from irradiated or intact donor rats. Donor rats were irradiated at 500 uW/cm² for 7 hr/day for 30 days. Exposure to SHF EMF resulted in marked stimulation of autoimmune reactions; the average number of plaque-forming cells at the end of the gestation period was 7.3% compared with 1.1% in intact controls. Irradiation of pregnant females caused inhibition of immunogenesis estimated by phytohemagglutinin-induced lymphocyte blast transformation (24.6% compared with 41.7% in controls). Immunization with serum from intact rats did not affect the course of pregnancy, while immunization with serum from irradiated rats resulted in increased embryoletality and decreased viability of the offspring.

0808 CLINICAL ASPECTS OF THE EFFECT OF ALTERNATING MAGNETIC FIELDS ON POSTOPERATIVE

COMPLICATIONS. (Rus.) Verzin, A. A. (Dept. Eye Diseases, Eye Microsurgery Res. Lab., N. I. Pirogov Second Medical Inst., Moscow, USSR); Kolesnikov, L. N. *Vestn Oftalmol* (3):56-57; 1982 (2 refs).

The therapeutic efficacy of alternating magnetic fields (AMF) was studied in 33 patients with postoperative complications following eye surgery. The patients were divided into three groups: 18 patients with hypema following intracapsular cataract extraction (Group 1); 11 with partial postoperative hemorrhthalmos (Group 2); 4 with postoperative inhibition of the cornea with blood (Group 3). Patients from Group 1 were exposed to AMF (50-80 Oe) for 3 min session for 10 sessions while patients from Groups 2 and 3 were exposed to AMF (80-100 Oe) for 5-8 min session. After 2 to 3 AMF applications, > 75% of the patients in Group 1 exhibited resorption of hypema compared with 50% of the control group. All Group 2 patients showed complete restoration of corneal transparency. In Group 3, half of the patients showed resorption of the hemorrhage after 10 AMF applications versus 36.3% of the controls. AMF applications enhanced the normalization of visual acuity in patients in all 3 groups.

0809 MICROWAVE THERAPY. (Rus.) Kuleshova, Z. S. (Dept. Physical Therapy, Central Inst. Advanced Training Physicians, Moscow, USSR). *Vopr Kurortol Fizioter Lech Fiz Kult* 2:63-67; 1982 (no refs).

Indications for therapy with microwave (MW) radiation are outlined. Centimeter-band MW (2375 MHz, 12.6 cm) is generated by Luch-2 (20 W output power) and Luch-58-1 (150 W output power) units. Decimeter band MW (65 cm, 460 MHz) is generated by Romashka (20 W) and Volna-2 units. The duration of a single irradiation ranges from 5-10 min for Luch-2 and Romashka units to 10-20 min for Luch-58 and Volna-2 units. Patients are subjected to daily irradiations; the total number of applications per course ranges from 5 to 20. The therapeutic effect of MW radiation is associated with thermal and nonthermal actions. MW therapy is indicated for parodontosis, arthritis of the maxillo-temporal joint, inflammation of the paranasal sinuses, furunculosis, tonsillitis, chronic dermatoses, prostatitis, endocervicitis, chronic and recurrent nonspecific bronchopulmonary diseases in children, pyelonephritis in children, arthritis of the shoulder joint, osteoarthritis of the ankle joint, coxarthrosis, osteochondrosis, rheumatoid arthritis, bronchial asthma, chronic pneumonia, peptic ulcer, chronic gastritis with hyposecretion, chronic colitis, chronic adnexitis, lactation mastitis, hypertension, renovascular hypertension, vibration disease, chronic pyelonephritis, and atherosclerosis of cerebral vessels. MW therapy is contraindicated in patients with cancer, active tuberculosis, fever, hemorrhages, thyrotoxicosis, and cardiovascular insufficiency.

- 1981, "CURRENT TERRAPIN RESEARCH IN THE UNITED STATES",
 FIELD, "TERRAPIN RESEARCH IN THE UNITED STATES",
 Field Res. Inst., National Institute of Environmental Health
 Science, Dept. Vertebrate Biology, Research Triangle Park,
 N.C. 27709, 1980 (20 pgs.).

Various therapeutic apparatuses generating a magnetic field sources are being used. The field parameters in the body depend upon the magnetic field frequency, the type of source, its size and shape. A magnetic field is characterized by the vector of magnetic induction, B . The vector density of magnetic fields is characterized by the gradient of magnetic induction. The magnetic field source (inductor or magnet) is the part of all devices for magnetotherapy. The Polius-1, a portable apparatus for low-frequency magnetotherapy, the Polius-1, consists of 1-2 inductors operated by a sine-modulated or pulsed 50-Hz current. The Farman apparatus, the Magnetodilux, consists of 12 solenoids operated by pulsed 50-Hz and 1-kHz currents. The Soviet portable apparatus, the Polius-101, consists of two solenoids generating a sine-modulated 50-Hz magnetic field; magnetic induction at a distance of 8 cm from the center of the solenoid is at least 1 mT (10 gauss). The most common type of permanent magnets (sheet application of the magnets) include the treatment of surface wounds and various proctological and gynecological diseases. The maximum magnetic induction at the surface of the applicator is 35 mT (350 gauss).

- GR13 A DEVICE FOR EXPOSING TO CONSTANT MAGNETIC FIELD
MATERIALS TO CONSTANT MAGNETIC FIELD
(Rus.) Golinskaia, M. S. (Experimental Dept., Central Inst. Balneology & Physical Therapy, Moscow, USSR); Kozlov, G. D. *Vopr. Fizioter. Fiziol. i Fiz. Kult.* (3):65-66; 1982 (no refs).

A special apparatus was developed to provide a more exact localization of constant magnetic fields in given body areas of small laboratory animals. The device consists of 2 ferrite magnets with two concentrators for the magnetic flux. The intensity of the magnetic field between the concentrators was changed by insertion of paper liners. The magnet was in the shape of a 20x18x1-cm plate. The magnets were placed in plexiglas containers 4x4x1-cm attached to vertical stands. The area of the plate of the concentrator was equal to the area of the magnet. Changes in the concentration possible by 180 degrees adjusted the magnetic field distribution between the concentrators.

- 1974 RECOMMENDATIONS OF THE BOARD OF PHYSICAL THERAPY OF THE USSR ACADEMY OF MEDICAL SCIENCES IN THE FIELD OF MECHANISM OF ACTION AND CLINICAL APPLICATION

TIONS OF MAGNETIC FIELDS. (Rus.) Balneology & Physical Therapy Res. Council (USSR Acad. Medical Sciences). Vopr Kurortol Fizioter Lech Fiz Kult (3):68-69; 1982 (no refs).

Methodological Guidelines for experimental and clinical studies have been developed to coordinate research on the biological effects of magnetic fields (MF). Reports should include the following: type of apparatus, type of MF (constant or alternating), pulse duration and frequency, applicator type and size, inductivity in mTesla, location of the applicator, duration of exposures and total number of exposures. The effects of MF should be recorded after the 1st, 5th, and 10th exposures, and following completion of the treatment. Recommendations include the use of MF with inductivity of 3-30 mTesla, a distance of 0-5 cm between the constant magnet or the inductor and the body surface, exposure duration of 10-30 min, and a total of 10-30 exposures. The biological effects studied should include hemodynamic indices, blood coagulation, hematocrit, erythrocyte sedimentation rate, cell membrane permeability for inorganic ions, free radical oxidation, membrane potential, electron paramagnetic resonance, and water structure. Therapeutic efficacy of MF should be tested in patients with acute and chronic aseptic and infectious inflammations of the locomotor apparatus, peripheral nerve diseases, vascular diseases and dystrophic skin diseases.

0815 ALL-UNION SYMPOSIUM ON PHYSICO-CHEMICAL MECHANISMS OF THE BIOLOGICAL ACTIVITY OF STATIC AND LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Kuznetsov, A. N. (Moscow, USSR); Shtemler, V. M. Vopr Kurortol Fizioter Lech Fiz Kult (3):70; 1982 (no refs).

The agenda of the First All-Union Symposium on Physico-Chemical Mechanisms of the Biological Activity of Static and Low-Frequency Electromagnetic Fields is outlined. The symposium was held 19-20 October 1981 in Pushchino, USSR. Six reports and 18 communications were presented. The reports summarized the results of studies of the effects of electromagnetic fields on free radical biochemical reactions, liquid crystal structure of cell membranes, and ferromagnetic inclusions in biological materials. The symposium emphasized the need for further evaluation of maximum permissible levels of exposure to electromagnetic radiation.

0816 EFFICACY OF DECIMETER-BAND WAVES AND MAGNETOPHORE THERAPY IN PATIENTS WITH HYPERTENSION. (Rus.) Orzheskovskii, V. V. (Dept. of Physical Therapy, Inst. Advanced Training for Physicians, Kiev, USSR); Chupchik, D. I.; Eastykovskii,

A. G. Vrach Delo (Kiev) 1982; 17:10-11 (no refs).

Comparative therapeutic efficacy of the magnetophore therapy and decimeter band waves (low frequency) in a clinical comparison. (Rus.) Orzheskovskii, V. V.; Chupchik, D. I.; Eastykovskii, A. G. (Dept. of Physical Therapy, Inst. Advanced Training for Physicians, Kiev, USSR). Vopr Kurortol Fizioter Lech Fiz Kult (3):69-70; 1982 (no refs). With 2 patients. The BW therapy resulted in a significant improvement in the appearance of headache, decrease in blood pressure, improvement of the therapeutic indices, and improvement of the coronary circulation. In 10% of the patients, a 5% weight loss improvement, a 10% decrease in diastolic blood pressure, and a 10% decrease in the BW therapy was achieved. Magnetophore therapy (application of a constant magnetic field) and decimeter band waves (low frequency) produced similar improvement in blood pressure, weight loss, and improvement of the coronary circulation. The magnetophore therapy was effective in the treatment of hypertension after magnetophore applications.

0817 THE EFFECT OF AN ELECTRIC FIELD OF INDUSTRIAL FREQUENCY ON THE INDICES OF NATURAL IMMUNITY. (Rus.) Likhachev, S. A. (A. N. Matveev Fed. Inst. General & Community Hygiene, Kiev, USSR). Vrach Delo (Kiev) 1982; 17:10-11 (no refs).

The results of comprehensive studies of the effects of electromagnetic (EM) fields of industrial frequency (50 Hz) on natural immunity are reported. Chronic exposure of rabbits (10 kV/m, 2 hr/day, for 2 mo) resulted in a transient decrease in blood bactericidal activity and beta-lysine levels. Exposure of male albino rats for 2 hr/day to 50 Hz EM fields with intensities of 1, 2, 4, 7, and 15 kV/m caused a transient increase in blood complement activity in animals exposed to 7 and 15 kV/m, while blood bactericidal activity in rats exposed to 50 Hz EM fields did not differ from that in controls. Exposure of human volunteers at 5 kV/m for 2 hr/day for 1 mo did not change complement and lysozyme titers. Exposures to EM fields with intensities of 12 and 15 kV/m (30 min 3/day with 1 hr intervals between the exposures for 10 days) resulted in slight and transient elevation of the complement titer, complement titer and blood bactericidal activity did not differ from those in controls. These findings can be used for the establishment of maximum permissible levels of exposure to 50 Hz EM fields for residential areas.

0818 MORPHOLOGICAL CHANGES IN CENTRAL NERVOUS SYSTEM NEURONS AFTER EXPERIMENTAL EXPOSURE TO CENTIMETER-BAND ELECTROMAGNETIC WAVES. (Rus.) Belokobitskii, V. S. (A. N. Matveev Fed. Inst. General & Community Hygiene, Kiev, USSR).

Current Literature

Vrach Delo (80):105-109, 1982 (13 refs).

The effects of centimeter band (CB) electromagnetic fields (EMF) on the morphology of central nervous system neurons were studied in dogs and cats. CBEMF were generated by a Luch-58 apparatus. The animals were exposed to CBEMF of thermal intensities (400-500 mW/cm²); dogs were irradiated for 4 hr and cats for 1 hr. Morphological changes in the central nervous system included swelling of the neurons, displacement of the nucleus, irregular contours of cell and nuclear membranes, redistribution of chromatin, and the appearance of vacuoles. The most pronounced changes were observed in neurons from the hypothalamus, limbic area, and temporal lobe. The neurons from the sensorimotor cortex, reticular formation, brain stem, and cerebellum were least affected by CBEMF. Exposure to CBEMF caused morphological changes in the neurons from all regions of the spinal cord.

0819 EFFECT OF IRRADIATION AFTER COMBINED EXPOSURE TO LEAD AND LOW-FREQUENCY ELECTROMAGNETIC FIELDS. (Rus.) Gerasimov, M. G. (Lab. Functional Diagnosis, Res. Inst. Industrial Hygiene and Occupational Diseases, Centr. Medical Radiology, Inst. for Advanced Training of Specialists, Kiev, USSR); Gerasimov, E. A.; Vrach Delo (10):94-111, 1982 (6 refs).

The state of liver circulation was studied in 218 workers who had an occupational exposure to lead vapors and/or super-high frequency electromagnetic (EM) fields. The lead levels and EM field exposures were within the maximum permissible exposure limits. The workers exposed to the EM fields alone showed a significant decrease in liver clearance, inhibition of liver excretory function, and a decrease in the accumulation capacity of liver cells. The changes in liver circulation after combined exposure to lead and EM fields were similar to those after exposure to EM alone.

0820 BRAIN AND LIVER METABOLISM AFTER EXPERIMENTAL EXPOSURE TO SHF-FIELDS OF NONTHERMAL INTENSITIES. (Rus.) Bolokritskii, V. S. (A. N. Sechenov Res. Inst. General & Community Hygiene, Kiev, USSR); Tomashevskaya, L. A. Vrach Delo (10):106-112, 1982 (20 refs).

The effects of superhigh frequency (SHF) electromagnetic fields on brain and liver metabolism were studied in albino rats. The SHF fields were generated by a Luch-58 apparatus (12.6 cm wavelength). The animals were irradiated at 50 uW/cm² (6 hr/day for 10 days). On day 30 after the last exposure, the rats were subjected to a single irradiation at 500 uW/cm². The metabolic activity of the brain and

liver was estimated by levels of DNA, RNA, and lipid concentrations and by activities of aspartate aminotransferase (SHF), malate dehydrogenase (MDH), aspartate dehydrogenase (ADH), and lactate dehydrogenase (LDH).

SHF fields (50 uW/cm²) resulted in significant activation of SHF, MDH, ADH, and LDH in the brains and hepatocytes, marked inhibition of the oxidative phosphorylation in brain and liver mitochondria, and a mild increase in DNA and RNA levels. Normalization of the histochemical and biochemical findings was observed 1-2 mo after termination of irradiation. Preliminary exposures to low intensity SHF fields increased resistance of animals to irradiation at 500 uW/cm².

0821 EFFECT OF LOW-INTENSITY SHF-ENERGY ON RESPIRATION AND OXIDATIVE PHOSPHORYLATION IN MITOCHONDRIA AND ACTIVITIES OF VARIOUS BLOOD ENZYMES. (Rus.) Rudnev, M. I. (A. N. Sechenov Res. Inst. General and Community Hygiene, Kiev, USSR); Tarasius, N. E.; Fudisova, A. B. Vrach Delo (10):93-95, 1982 (7 refs).

The effect of a superhigh-frequency (SHF) electromagnetic field (EMF) on energy metabolism was studied in random-bred albino rats. The animals were exposed to SHF EMF generated by a Luch-58 apparatus (wavelength of 12.6 cm) at a power flux density (PFD) of 50 uW/cm² (1 hr/day for 5, 10, 20, or 30 days) or at 500 uW/cm² (single 4-hr exposure). The metabolic changes were estimated by respiration and oxidative phosphorylation in liver and brain mitochondria and by activities of serum transaminases and alkaline phosphatase. Repeated irradiation at 50 uW/cm² resulted in temporary inhibition of respiration, an increase in serum aspartate aminotransferase and marked inhibition of alanine aminotransferase and alkaline phosphatase activities. The significant decrease in blood glucose levels on days 1 and 5 after exposure to 50 uW/cm² was indicative of enhanced glycolysis. Single irradiation at 500 uW/cm² failed to induce significant changes in liver and brain mitochondria.

0822 THE EFFECT OF A CONSTANT MAGNETIC FIELD ON EPILPTOGENIC FOCI IN RABBIT HIPPOCAMPUS. (Rus.) Tyvin, L. I. (Medical Pediatric Inst., Leningrad, USSR); Zh. Vyssh. Nerv. Sist. (32):100-105, 1982 (19 refs).

The effects of heterogenous magnetic fields (MF) on the functional activity of the hippocampus were studied in rabbits. The animals were subjected to administration of 0.01 ml of penicillin solution into the left or right hippocampus. Penicillin infection produced marked changes in electroencephalogram activity and development of epileptogenic

discharges. Immediately after development of the epileptogenic foci, the elastic magnets were placed above the right and/or left hippocampus. The maximum induction of MF at the magnet surface was 18 or 28 mTesla, the gradient was 30 or 45 mTesla/cm, and the average induction in the area of the epileptogenic focus was 0.3 or 0.5 mTesla. Exposure to a weak heterogeneous MF produced marked stimulation of epileptogenic activity. MF enhanced the epileptogenic activity of the left hippocampus. The mechanisms of the stimulating effects of MF were associated with MF-induced hyperplasia of the glial cells, hypoxic state of brain structures, changes in glycogen metabolism, and changes in neuronal membrane permeability.

0823 ELECTRICAL AND ELECTROMAGNETIC EFFECTS ON OSTEOGENESIS AND BONE GROWTH (EDITORIAL). (Ger.) Ungethüm, M. (Aeskulapwerk, Postfach 40, D-7200 Tuttlingen). Munch Med Wschr 124(26):621-622; 1982 (6 refs).

Methods of therapeutic electric osteostimulation and their evaluation are discussed. Current commercial electrical osteostimulation methods are so different in principle and design that it is impossible to evaluate them relative to one another. Electric osteostimulation seems to be indicated in the case of fractures in which repeated surgical interventions were unsuccessful. Ultrasound absorption measurement, x-raying after venography, transcutaneous measurement of the fracture potential, and double-blind methods are available for evaluating the effectiveness of electrical osteostimulation. The problem of quantitative evaluation of therapeutic effects is illustrated by the treatment of loosened total endoprostheses with purely magnetic fields, in which no radiological changes are apparent, even though subjective results suggest the effectiveness of this method. Surgery combined with electrodynamic field therapy was successful in more than 93% of 351 patients with mostly atrophic pseudarthroses of low reactivity after several unsuccessful operations. Electrical osteostimulation improves the retention of autologous spongiosa transplants.

0824 APPLICATION OF PHARMACOLOGICAL METHODS TO THE STUDY OF BIOLOGICAL EFFECTS OF MICROWAVE RADIATION DURING LOW-LEVEL IRRADIATION. (Fre.) Klein, M. J. (Div. neurophysiologie appliquee, Centre d'etudes et de recherches de medecine aerospaciale, 26, blvd. Victor, 75996 Paris Armes); Steru, L.; Milhaud, G. L.; Rosolen, S. G. Radioprotection 17(4):225-241; 1982 (34 refs).

Synergistic effects between microwave (MW) radiation and psychopharmacologic agents were investigated in 813 mice and 120 rats. Charles River mice

and Wistar rats were exposed to MW power (2.45 GHz, continuous wave, 12.25 cm wave length) produced by an industrial generator (Thomson CNE 12.1, 100 W output power) for 30 min at power densities of 1 and 5 mW/cm². No significant difference was observed in motor activity between irradiated and control mice injected with various dosages of d,l-amphetamine sulfate or l-amphetamine sulfate immediately before exposure. MW irradiation had no effect on the incidence or severity of stereotypic events in rats receiving d,l-amphetamine sulfate or apomorphine chlorhydrate before exposure. MW irradiation either before or after administration of the convulsant agents bicuculline and caridazol to mice had no effect on the chronology of convulsions or their average duration; thus exposure to MW did not interfere with the metabolism of the convulsants in mice. There was no evidence of blood brain barrier permeability in mice receiving oxotremorine plus methylatropine before MW irradiation. In motor activity tests in mice, irradiation at 2 mW/cm² significantly potentiated the sedating effects of a 5 mg/kg dose of chlordiazepoxide; the effect was not statistically significant at other dose levels. Although the rectal temperature of control mice was not affected by irradiation at either power level, mice with hypothermia induced by injection of oxotremorine and apomorphine had significantly higher rectal temperatures after irradiation than nonirradiated mice.

0825 IMPACT OF LOCALIZED MICROWAVE HYPERTHERMIA ON THE pH-DISTRIBUTION IN MALIGNANT TUMORS. (Ger.) Vaupel, P. (Physiologisches Inst., Univ. Mainz, Saarstrasse 21, D-6500 Mainz, W. Germany). Strahlentherapie 158(3): 168-173; 1982 (34 refs).

The effect of localized microwave (MW) hyperthermia (2.45 GHz, 43 °C for 1 hr) on pH distribution in mammary adenocarcinoma was studied in 12 female C57BL/6J mice 10-20 days after sc tumor implantation into the lateral femoral region. Treatment was performed with a special MW applicator connected to a Raytheon magnetron (model CMD-10). Glass pH microelectrodes were used to measure pH values. The mean pH value measured in small tumors weighing < 1.0 g and without appreciable necrosis was 6.75 (6.2-7.0) immediately before hyperthermia. Immediately after tissue temperature returned to the initial value after hyperthermia, the mean pH was 6.21 (5.7-6.9). The reduction in pH value was statistically highly significant (2p < 0.005). The mean pH was 7.21 in large tumors (1.1-1.5 g) in which more than 50% of the tumor mass was necrotic. The pH values were significantly higher than in small, nonnecrotic tumors, but showed inhomogeneous distribution. Hyperthermia caused no significant changes in pH in the large tumors. The findings indicate that MW hyperthermia markedly intensifies preexisting tissue acidosis, but causes no significant changes in the pH value in the case of more alkaline values.

1. The first step is to identify the key components of the system. This includes understanding the hardware, software, and data involved.

results obtained in the treatment of human patients are also encouraging. In the treatment of fracture nonunion, possibly the most difficult of fracture sites and also one of the most common causes of clinical studies, we have observed healing of large fractures in human beings after treatment. The treatment had no effect on the osteocytic index compared to untreated controls. Female females with nonunions after rat bite injury were treated with specific pulsed electromagnetic diode laser radiation. Histological and radiologically manifest consolidation, decrease in osteocytic activity in the region of the fracture and mineralization of the fibrous tissues as well as vascularization were observed after 4 days.

0828 ON THE PROBLEM OF THE HAZARDS OF DOWNLOADING
AND PUBLISHING - MICROWAVES, LASERS, ETC.
Florian, H. J. (Hann. Mediz. & Arbeitsmedizin, Berufserkrankungs- u. Arbeitswissenschaftl. Inst., 30559 Hannover, Germany). *Journal of Occupational Medicine and Biodynamics*, 1998, 19, 1, 1-10.

The health hazards of microwave (MW) radiation and related safety standards are reviewed. The depth of penetration and absorption rate of MW are frequency-dependent. The absorption rate is nearly 100% in the 1-3 GHz range in which most radar equipment operates. The safety standards established on the basis of the thermal effect of MW radiation is 10 mW/cm^2 , which corresponds to an increase of 1°C in body temperature during continuous irradiation of a body surface of 1 m^2 with 1 W . Exposure of the crystalline lens and of the testicles are most relevant medically in connection with radio-body irradiation. Transient infertility was observed after exposure of testicular tissue to MW energy at densities above 1 mW/cm^2 . Development of cataract was observed in persons exposed occupationally to MW periodically at several times at levels exceeding 100 mW/cm^2 . However, extensive clinical studies on exposed military and civilian personnel failed to show any increase in the incidence of cataracts when any and various synergistic effects (metabolic disorders, environmental factors, and drugs) were taken into account. An energy density $> 10 \text{ mW/cm}^2$ at an exposure duration of $> 10 \text{ min}$ can be considered to be the threshold level for cataract formation in the frequency range 1-3 GHz, as determined in rabbits. The critical temperature of the media of the eye can be considered to be $> 45^\circ\text{C}$. The subthermal effects of MW include psychovegetative effects (changes in blood pressure and blood picture, and decreases in performance). However, there is no justification for lowering the safety standard in view of such long-term, low level effects, even though further studies are necessary. The energy flux density during short-term exposure (e.g., 1-3 min) should not exceed the thermal threshold level for cataract.

MEETING ABSTRACTS

829 TECHNICAL ASPECTS OF HEAT DELIVERY (MEETING ABSTRACT). (Eng.) Hard, J. W. (MRC Cyclotron Unit, Hammersmith Hosp., London W12, England). Br J Radiol 55(660):941; 1982.

The use of non-ionizing electromagnetic waves (microwaves and radiofrequency) and ultrasound to induce hyperthermia in patients was briefly reviewed. The advantages and disadvantages of a number of techniques were explained through reference to simple physical considerations. The techniques discussed included aperture microwave (MW) sources, interstitial and intracavitary MW sources, localized current fields, interstitial ferromagnetic seeds, capacitive coupling of radiofrequency (RF), inductive coupling of RF and focused ultrasound. The problems associated with heating deep tissues were also addressed, with an emphasis on those techniques commercially available. The availability of non-invasive thermometers was discussed. Until the advent of suitable non-invasive thermometry, information concerning temperature distributions achieved during therapy will be acquired through a necessarily small number of invasive thermometers. The implications of this limitation in thermal dosimetry for the effectiveness of hyperthermal treatments were outlined.

830 MICROWAVE RADIATION EXPOSURE INDUCES TRANSLOCATIONS AND UNIVALENTS DURING SPERMATOGENESIS IN MICE (MEETING ABSTRACT). (Eng.) Manikowska-Czerski, E. (Bureau Radiological Health, FDA, HHS, 5600 Fishers Lane, Rockville, MD). J Cell Biol 95(2):A301; 1982 (ref).

In attempts to clarify inconsistent and contradictory results from dominant lethal testing of microwave exposed rodents, cells were examined from testes of mice. For examination, cells were prepared with a modified Meredith technique. Irradiations were at frequencies of 0.915, 2.45, and 9.4 GHz, continuous wave, and 9.4 GHz pulsed, with whole body average absorbed dose rates of 0.05, 0.5, 1, 5, 10, and 20 mW/g. Spermatogonial and spermatocyte I and II metaphases were counted and examined for chromosomal abnormalities. Metaphase numbers decreased below control values at low dose rates, and increased at high dose rates. A dose rate dependent increase in translocations was observed. The incidence of univalency increased at 10 and 20 mW/g. The findings are interpreted to indicate interference with normal spermatogenesis during late spermatogonial and spermatocyte prophase I stages. Further, inheritance of the chromosomal changes seems a possibility.

831 PULSED ELECTROMAGNETIC FIELD EFFECTS ON CELLULAR REGULATION OF PROTEIN SYNTHESIS (ABSTRACT). (Eng.) Goodson, E. (Dept. Pathology, Cell, Physicians & Surgeons, Columbia Univ., New York, NY); Rossett, C. A. (J. Neurosci., A. J. J. Cell Biol 95(2):A474; 1982.

The functional and temporal pattern of general cellular metabolism can be altered by changes in the electrical environment. It was hypothesized that exogenously administered pulsed electromagnetic fields (PEMFs) can be used to trigger prescribed cellular responses. This has been tested in a study of pattern alterations in specific cellular events in the polytene salivary gland chromosomes of the dipteran *Sciara coprophila*. The experimental design uses both cytological and biochemical methods to follow alterations in the pattern of genetic activity resulting from the use of PEMFs alone or in combination with hormonal induction of pupis, heat shock and variation in the ionic environment. Alterations in transcription and translation were monitored by sucrose gradient centrifugation, gel electrophoresis, cytological nick-translation and transcription autoradiogram. Specifically, both repetitive single pulse (RSP) and repetitive pulse burst (RPB) induced alterations in transcriptional events up to 60 min. The effect of RPB is an increase in RNA synthesis in all size classes following 45 min of pulse. RSP, however, induced a 10-fold increase in the specific activity of mRNA at 15 and 45 min of pulse. This is reflected in the protein synthetic pattern. The results suggest that the two signals evoke distinctly different cellular responses. Induction is influenced by the type of pulse as well as the cellular environment. The recognition of mediating factors in the use of PEMFs should allow us to define more specifically the role of electrical fields in the normal function of the cell.

832 RADIOFREQUENCY HAZARDS IN THE VLF TO MF BAND (MEETING ABSTRACT). (Eng.) Gandhi, O. P. (Dept. Electrical Engineering, Univ. Utah, Salt Lake City, UT 84112); Chatterjee, I. J. Microwave Power 17(4):323; 1982.

The paper gives the currents that can flow through a human body for conditions of conductive contact with ungrounded metallic objects such as cars, trucks, fences, etc. These are then compared to the threshold currents for perception and let go, for frequencies in the 10 kHz - 10 MHz range, deriving thereby the incident electric field intensities for these phenomena to occur. It is shown that the ANSI proposed guideline of 100 mV/cm (approximately 0.15 V/m) in the frequency band 30 kHz - 3 MHz may result in a potential for radiofrequency burns for conditions of conductive contact with these commonly encountered metallic objects.

- We have previously shown that the growth of the tumor is inhibited by the combination of the immunomodulatory agent, IFN- γ , with the chemotherapeutic agent, cisplatin. In this study, we have evaluated the effect of IFN- γ with cisplatin, with or without the immunomodulatory agent, PBEA, on the growth of the tumor. Mice were treated with cisplatin with or without PBEA or cisplatin with or without IFN- γ for 12 weeks. The results show that the median survival time of the mice was significantly increased by PBEA or IFN- γ alone vs. untreated controls. However, a synergistic response, in terms of survival time to 12 wk, was observed in mice treated with PBEA and IFN- γ . These results provide evidence for an effective and nontoxic anticancer modality. Histology showed enhanced necrosis for PBEA-exposed tumors, suggesting a possible synergistic synergy with the macrophage and NK-cell stimulating PBEA.

- Radiofrequency radiation (RF-EMF) is thought to be associated with brain wave frequencies and, therefore, causes changes in the rate of release of intracellular calcium ions from the endoplasmic reticulum. However, only specific frequencies of radiofrequency radiation are effective. Experiments with correlated 50-MHz radiation produce similar but not identical findings. The results at different carrier frequencies can be reconciled if the fundamental variable is taken to be the intensity of the electric field within the tissue rather than the intensity of the electric field in free space.

0817 AN ELECTROCHEMICAL FIELD ANALYSIS OF THE
HELMHOLTZ DOUBLE LAYER DELIVERY FOR BIOLOGICAL
STUDIES (MEETING ABSTRACT). (Engl.) Melmed, B. E.
(Dept. Electrical Engineering & Computer Science,
Montana State Univ., Bozeman, MT 59717), Samelson,
M.; Pilla, A. A. J. Electrochemical Soc., 130, 1,
1983.

- Helmintholizoids that are being used in biological systems are examined. The well-known but complex fields (animals, are presented in graphical form for ease reference. An analysis is also done on an in vitro system in the growth field region of the cells. Also in a experimental data are presented and compared. The attention is directed at utilizing the cells.

perturbation given to a living cell by the Helmholtz coils.

- 0838 EFFECTS OF ELECTROMAGNETIC FIELDS ON THE CELL SURFACE (MEETING ABSTRACT). (Eng.) Marron, M. T. (Biomedical Res. Inst., Univ. Wisconsin-Parkside, Kenosha, WI 53141); Goodman, E. M.; Greenbaum, B.; Luzander, S. J Electrochem Soc 129(3):1330; 1982.

Effects on the cell surface of Physarum polycephalum amoebae grown in 60 Hz sinusoidal field of 1.0 V/m and 1.0 G can be detected using aqueous two-phase partition chromatography. We report the first direct observation of cell surface effects due to weak, low frequency electromagnetic fields.

- 0839 THE EFFECT OF PULSED ELECTROMAGNETIC FIELDS (PEMFs) ON RNA TRANSCRIPTION IN POLYTENE CHROMOSOMES (MEETING ABSTRACT). (Eng.) Goodman, R. (Dept. Pathology, Columbia Univ., New York, NY 10032); Henderson, A. S.; Bassett, C. A. L. J Electrochem Soc 129(3):1330; 1982.

Using tritiated uridine incorporation to monitor transcription, RNA was extracted from control and PEMF-treated (single pulse and pulse train) salivary gland cells at 15 min intervals up to 2 hr. Cytologically transcription was monitored by transcription autoradiographically. Biochemically PEMFs induced a marked increase in the specific activity of RNA: (i) the single pulse induces increased specific activity of presumptive messenger RNA (6S-17S) at 15 and 45 min; (ii) the pulse train induces one peak of activity at 45 min in the 18S region; (iii) following peaks in RNA activity induced by PEMFs, fall-off in transcription is sharp and after 60 min, and more prolonged PEMF treatment, specific activities fall below control levels; (iv) the effect of sudden elevated temperature (heat shock) and PEMF together produce a synergistic effect; and (v) by taking the cells in and out of the field, it is apparent that the reduced rate of transcription resulting from long time periods in PEMFs can be reversed. Studies on this rebound effect are discussed.

- 0840 THE EFFECT OF PULSATING ELECTROMAGNETIC FIELDS (PEMF) ON OSTEOBLAST-LIKE CELLS IN CULTURE (MEETING ABSTRACT). (Eng.) Rodan, G. A. (Dept. Oral Biology, Univ. Connecticut Sch. Dental Medicine, Farmington, CT 06032); Johnson, D. E. J Electrochem Soc 129(3):1330; 1982.

The object of this investigation was to study the mechanism through which PEMF promotes fracture healing. In this study we report the establishment of an experimental system in which PEMF elicits reproducible effects on osteoblast-like cells in culture. Under growth restrictive conditions (in early cultures and at confluence), PEMF stimulates proliferation. This effect is associated with a postponement of phenotypic maturation, as measured by alkaline phosphatase levels. The PEMF effects were proportional to the repetition rate of PEMF in the range of 5-25 Hz. The time course and the phenotypic nature of PEMF effects are similar to hormone effects in this system.

- 0841 EFFECTS OF INDUCED ELECTROMAGNETIC FIELDS ON THE HORMONAL RESPONSES OF BONE AND BONE CELLS IN VITRO (MEETING ABSTRACT). (Eng.) Liben, R. A. (Div. Biomedical Sciences, Univ. California, Riverside, CA 92521); Cain, C. D. J Electrochem Soc 129(3):1330; 1982.

The effects of pulsed electromagnetic fields on bone healing are well known. However, the molecular and cellular actions of these fields remains obscure. The current study examined the effects of clinically useful fields on bone and bone cells in tissue culture. Exposure of cells to "bio-stimogen" fields produced significant inhibition of several biochemical responses to parathyroid hormone (PTH), suggestion that some or all of the in vivo actions of the fields may be mediated by blocking the osteolytic effects of PTH in localized areas. Studies were also performed to examine the role of the fields in stimulating differentiation of precursor cells into osteoblasts. Further results are discussed.

- 0842 PULSED ELECTROMAGNETIC FIELD EFFECTS ON CHONDROBLAST CULTURE (MEETING ABSTRACT). (Eng.) Norton, L. A. (Univ. Connecticut Health Center, Sch. Dental Medicine, Farmington, CT 06032). J Electrochem Soc 129(3):1330; 1982.

Changes in products of differentiation were measured in cultured chondroblasts exposed to a pulsed electromagnetic field (PEMF) for 48 hr. Relative to control groups, PEMF cultures had a decreased glycosaminoglycan, and increased DNA and a changed hydroxyproline content per μ g DNA. The lysozyme activity increased 7x, the hyaluronidase in the medium increased, while the total protein of the cultures decreased. Chitosanase, a specific lysozyme inhibitor, abolished the PEMF effects. Addition of exogenous lysozyme augmented the effects. Increase in lysozyme activity in the presence of PEMF was seen when cycloheximide was added to the culture. Thus, lysozyme appears to be a

On 11/11/1964, Mr. J. Edgar Hoover advised that the FBI was not aware of any information regarding the activities of the "Black Liberation Army" or "Black Liberation Movement" in the United States. He stated that the FBI was not aware of any information regarding the activities of the "Black Liberation Army" or "Black Liberation Movement" in the United States. He stated that the FBI was not aware of any information regarding the activities of the "Black Liberation Army" or "Black Liberation Movement" in the United States.

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These findings are consistent with reports designed to couple to electrical fields at the cell surface have been shown to have a considerable biological effect in a variety of systems and in vivo cell systems, including the potential application to heal recalcitrant wounds and fractures. This study extends the existing information transfer approach to a novel approach in active ion transport. It is a significant departure of all existing correlations between induced current waveform parameters and the biological processes as active ion transport, cell differentiation, and radial osteogenesis in the rat, strongly suggests that electromagnetic current induction operates via electrical pathways very fundamental to cell differentiation.

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at 1, 5, 10, and 15 Hz, and depressed at 1 Hz with respect to the controls.

848 ALTERED BIOLOGICAL RESPONSES IN PARAMEC-
IUM INDUCED BY RF-EMF PULSATION (MEETING
ABSTRACT). (Eng.) Smith-Sonneborn, J. L.
(Dept. Zool. & Physiol., Univ. Wyoming, Laramie, WY
82071); Pilla, A. A. J. Electrochem Soc 129(3):1420;
1982.

The biological response of the single-celled organism *Paramecium* to specific pulsating current was monitored with respect to longevity and length of cell cycle. *Paramecium* are eukaryotic protozoan cells which can be viewed as excitable cells capable of generating receptor and action potentials in response to proper electrical, mechanical, or chemical stimuli. Clonal aging in *Paramecium* provides a model system of cellular senescence which exhibits a species-specific number of cell divisions since the previous fertilization. Cells cultivated continuously in pulsating currents showed significantly ($P < 0.05$) increased survival relative to controls in response to current signals. The induced voltage was obtained using air-gap coils driven by a programmable power supply (Electro-biology Corp., Fairfield, NJ). The length of the cell cycle was found to be modulated in response to specific pulsating current and was a function of current density.

849 A CELL ELECTRICAL SIMULATION ACCOUNTING
FOR ION TRANSPORT AND ABSORPTION PROCESSES (MEETING ABSTRACT). (Eng.) Prado, G. P.
(Istituto Circuiti Elettronici-C.N.R. 16135 Genoa, Italy); Marchesi, M.; Ridella, S. J. Electrochem Soc 129(3):1320; 1982.

A multilayer spherical structure, simulating a cell, is studied under the influence of an alternate electric field. Refining previous works, the cell membrane and the cell nucleus are simulated accounting for ion fluxes and binding processes under linear hypothesis. The parameters of the model are obtained from data of experimental origin. The main quantities of physical and biological interest and their transfer functions, with respect to the external electric field, are computed within each layer. Many of these quantities present multimodal behaviors against the frequency, sometimes with strong maxima of particular interest (e.g. ion concentrations and fluxes).

850 ELECTRIC FIELD MEDIATED ION TRANSPORT
(MEETING ABSTRACT). (Eng.) Seto, Y. J.

J. Electrochem Soc 129(3):1320; 1982.

The effect of electric field perturbation on the functional transport of ions has been analyzed. The analysis reveals that periodic time-varying electric field may enhance or retard the ion transport depending on the intrinsic system parameters such as the diffusion resistance and ion turn over rate. The theoretical results also present some potential applications of electric fields in the kinetics of pharmacokinetic and localized enzyme systems.

851 ON-LINE SYSTEM IDENTIFICATION AND EQUIVA-
LENT CIRCUIT MODELING OF BIOELECTROCHEMICAL KINETIC PARAMETERS (MEETING ABSTRACT). (Eng.) Gert, G. (Dept. Physiology, Coll. Physicians and Surgeons, Columbia Univ., New York, NY 10032); Pilla, A. A. J. Electrochem Soc 129(3):1320; 1982.

The identification and estimation of the functional parameters in biological cell response to applied electrochemical stimuli has figured significantly in optimizing electromagnetically induced pulsed signals for clinical use. As it has been demonstrated that biological systems respond to stimuli of specific frequencies and amplitude, it is critical to accurately determine the time constants of cellular transient response. An on-line measurement and analysis technique has therefore been developed to resolve impedance data from 0-10 MHz. The existing frequency domain technique based on the Laplace transform has been replaced by a non-linear optimization algorithm and results have been obtained for amphibian epithelium and the human red blood cell.

852 OCULAR CHANGES INDUCED BY MICROWAVE DIATHERMY IN THE RABBIT (MEETING ABSTRACT). (Eng.) Miki, H. (Dept. Ophthalmology, Kansai Medical Univ., Japan); Doi, H.; Miki, K.; Okada, H. Jpn J Ophthalmol 26(1):135; 1982.

An apparatus for microwave (MW) coagulation was developed that emits pulse radiation with 2450 MHz and 0-200 W. The rabbit eye was irradiated under various conditions and the ocular changes were studied clinically and histologically. After irradiation with 30 W for 5-10 min, no particular change was noted. After irradiation with 50 W for 6-10 min, a slight cataract developed, and about 1 mo later the cataract was absorbed; subsequently the eye became shrunken. Destructive effects were mainly on the iris, ciliary body and lens, and the

1. *Pharmaceutical industry* – The pharmaceutical industry is the largest of the three industries, with sales of \$10.5 billion in 1997. It is the only industry that has a significant presence in all three markets.

1991). In fact, after tumor cells are exposed to MMS, the tumor cells are not able to repair the DNA damage that has occurred, resulting in at least one strand being cut and cell death. In fact, we have shown that tumor cells are not able to repair the DNA damage that is caused by MMS after a 10 minute exposure to this alkylating agent. When MMS was given to the mice prior to MMS there was a significant reduction in the uptake in all of the tumor types: T47D-2, MCF-7, IPR4-217. When MMS was given after MMS, there was no significant effect on MMS uptake in T47D-2 or MCF-7, while in IPR4-217 there was a slight decrease. The results indicate that the potentiating effects of MMS are probably not due to increased permeability of the tumor to the drug, and the MMS is probably not given after drug treatment.

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ceeds 43°C.

886 SYNERGY OF PYRAN CO-POLYMER (PYRAN) AND PULSATILE ELECTROMAGNETICALLY INDUCED CURRENTS (PEMIC) AGAINST B16 MELANOMA (M) IN VIVO. (MEETING ABSTRACT). (Eng.) Norton, L. (Mount Sinai School of Medicine, New York, NY 10029); Tansman, L. S.; Regelson, W.; Geller, S.; Pilla, A. A. Proc Annu Meet Am Assoc Cancer Res 23:193; 1982 (1 ref.)

The antineoplastic activity of the immunomodulating polyanion PYRAN, in clinical trial as MVE-2, is enhanced by simultaneous exposure of tumor-bearing mice to PEMIC, a nontoxic, low power, nonthermal, nonionizing current designed to influence membrane-enzyme electrochemistry. This extends the anticancer activity of PEMIC, which has already demonstrated a synergy with cytotoxic combination chemotherapy in the M system. One hundred female BDF₁ or B6F₁ mice were given no drug or PYRAN 75 mg/kg ip 1 or 7 days after sc implantation of 1 mm³ M. Mice randomized to receive PEMIC were placed 4/cage between air-gap coils (Electro-biology, Fairfield, NJ) inducing 2 Hz currents of 50 msec bursts of 250 msec main polarity, 4 msec opposite polarity, peak density 0.1-1 uA/cm², for 12 hr/day from day 2 continuously. Dummy cages were used for nonPEMIC mice. Species or day of therapy did not influence survival. At a median survival of 7 wk, 24 mice with PEMIC alone were not different from 28 mice with PYRAN alone or untreated controls, although 20% of PYRAN-only mice has a slight survival improvement. However, 20 mice with both PYRAN and PEMIC had a median survival in excess of 10 wk ($\chi^2 = 6.63$, $p < 0.05$). This was due to an inhibition of the initial pseudo-exponential portion of the Gompertzian growth curve, resulting in an overall displacement of the survival curve for 100% of mice. Histology suggested enhanced necrosis of PEMIC-exposed tumors, which suggests the mechanism of synergy with the macrophage and NK-cell stimulating PYRAN.

0857 SELECTIVE RESPONSE OF TUMORS TO MICROWAVE HYPERTHERMIA (MEETING ABSTRACT). (Eng.) Goldfeder, A. (Cancer & Radiobiological Res. Lab., New York Univ., New York, NY 10003); Perrino, P. Proc Annu Meet Am Assoc Cancer Res 23:220; 1982 (1 ref.).

Previous studies in this laboratory used microwave (MW) hyperthermia as an adjunct to x-irradiation and misonidazole. The present study is concerned with effects induced by MW hyperthermia alone. Two mouse mammary carcinomas (MT2, DBAH) and a spindle cell sarcoma (TEC) of standard size growing in isogenic hosts have been exposed to 4250 MHz induced MW hyperthermia at 42-43°C for a predetermined time

of 60 min for 5 days. Measurements of treated and control tumors were made daily. At 12-24 hr post-treatment the tumors increased slightly, presumably due to edema. Shrinkage of tumors started at about 48 hr later. Of the three types of tumors treated, the DBAH proved most thermosensitive, regressing completely within 2-3 wk after treatment. The MT2 carcinoma similarly treated formed a dark crust in the center while new growth appeared at the edge of the treated tumor. Of the TEC tumors treated daily for 60 min, 75% totally regressed, the remainder continued to grow at a slower rate. The results indicate a difference in thermoresponse among the three tumor types and emphasize the significance of studying each tumor type individually. The mechanism(s) of MW effects on cellular components is being studied by high pressure liquid chromatography and will be presented.

0858 CLINICAL PILOT TRIAL OF RADIOFREQUENCY (RF)-INDUCED REGIONAL HYPERTHERMIA OF SUPERFICIAL (SF) AND DEEP-SEATED (DS) TUMOR LESIONS (MEETING ABSTRACT). (Eng.) Choksi, J. (M. D. Anderson Hosp. and Tumor Inst. Houston, TX 77030); Corry, P.; Headley, D.; Bernadino, B.; Barlogie, M. D. Proc Annu Meet Am Soc Clin Oncol 1:21; 1982.

A clinical pilot trial was conducted to evaluate anti-tumor effects and toxicities of RF-induced regional hyperthermia for the treatment of recurrent SF (27 patients) and DS (6 patients) tumor lesions unresponsive to conventional therapy. Histologic diagnosis included 16 sarcomas, 11 breast cancer and 6 miscellaneous tumors. Treatment for 1 hr at a desired starting temperature of 43°C was administered daily for 5 days/wk for 2 wk followed by a 2 wk treatment-free interval. Subsequent heating was performed using gradual increments in temperature to a maximum of 52°C. A RF apparatus operating at 13.56 MHz served as a heating source. The maximum tumor temperature was independent of histopathology, size of treated lesions and prior exposure to ionizing radiation. The overall objective response rate for 25 evaluable patients receiving at least 5 consecutive treatments was 44% including 2 complete and 9 partial remissions. Three additional patients had a minor response. RF-induced anti-tumor effects were temperature-dependent, i.e. lack of tumor regression below 42°C including 8 SF and 3 DS tumor lesions; while 55% of 11 patients treated at 42 to 48°C responded, and heating to > 48°C induced responses in all 6 patients treated. Tumors treated at > 46°C showed longer remission duration than those treated at < 46°C. Pain was the treatment-limiting toxicity in 15 patients. Blisters were noted in 4 patients, and 1 patient each developed bleeding and infection. Thus, externally applied RF-induced regional hyperthermia is a safe and effective antitumor treatment modality with minimal biological effect at temperatures < 42°C, whereas higher temperatures produce tumor regression in half of the treated

Meeting Abstracts

*Biological and Medical Aspects of
Hyperthermia in Cancer Therapy*

patients.

9859 PRODUCTION OF WHOLE BODY HYPERTHERMIA BY MICROWAVE ENERGY (MEETING ABSTRACT). (Eng.) Bornback, N. B. (Indiana Univ. Sch. Medicine, Indianapolis, IN 46223); Shupe, R. F.; Morris, J. G.; Marshall, C. Proc Annu Meet Am Soc Clin Oncol 1:52; 1982.

Hyperthermia in cancer therapy has been viewed with increasing interest; however, an effective, reproducible method has been needed for local and whole body hyperthermia. A variety of techniques and equipment has been developed to produce localized hyperthermia with a fairly consistent degree of reproducibility. Whole body hyperthermia has been produced by either extremely expensive or mostly unsatisfactory methods including: 1) injection of bacterial toxins, 2) heated steam cabinets, 3) inhalation of heated gases with hot wax baths, 4) circulating heated water body suits, and 5) heated blood perfusion techniques. Over the past 18 mo, 29 patients with advanced cancer have undergone a total of 141 body hyperthermia treatments utilizing microwave generators. Core body temperatures of between 40.5 and 41.5 C were maintained for 60 to 120 min in these patients. The procedure and equipment used to produce the desired levels of temperature for varying periods of time provides a safe, reliable and inexpensive method for whole body hyperthermia. This simplified technique will be described in detail and preliminary results of therapy will be presented.

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OF ADAPTATION PROCESSES IN PERIPHERAL
CIRCULATION

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IMMUNITY OF IMMUNE AND ADULT CANCER
MALE FOR THE MICROWAVE RADIATION
DURING IMMUNITY (MORPHOLOGY).
1981

1. *Pharmaceuticals*

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1. The first step is to identify the key components of the system. This includes understanding the hardware, software, and data involved.

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INTERACTION OF AMBIENT TEMPERATURE AND
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2000

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USE OF MATHEMATICAL MODELS FOR ANALYSIS OF
OF AGGREGATION PROCESSES IN A RADIATION
FIELD. 1975.

ANALYSIS OF THE RADIATION FIELD IN
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ENERGY TRANSMISSION SYSTEMS: EFFECTS
OF 60-HZ ELECTRIC FIELDS ON BIOLOGICAL
AND CLIMATIC ENVIRONMENTAL AND
ENVIRONMENTAL FUNCTIONS. IN: SMALL GROUPS
(January 1, 1974; Conference 1, 1974).

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MODEL: THEROCHEMICAL

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1. The first step is to identify the problem or question that needs to be answered. This involves understanding the context and the specific requirements of the task.

1. The first group of authors (see Table 1) has been concerned with the question of whether the use of a particular type of stimulus material (e.g., pictures, words, or objects) is more effective than another type of stimulus material. The results of these studies are inconclusive. Some studies have found that pictures are more effective than words, while others have found that words are more effective than pictures. The results of these studies are inconclusive because the studies have not controlled for the effects of the stimulus material on the dependent variable.

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the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is expected to reach 1.7 billion by the year 2015.

the 1990s, the number of people in the United States who are 65 years of age or older has increased by 50% (U.S. Census Bureau, 1997). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 1997). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 1997). The number of people aged 65 and older is projected to increase to 20% of the total population by the year 2020 (U.S. Census Bureau, 1997).

1. 1990年12月25日，在俄罗斯莫斯科市，俄罗斯联邦总统叶利钦在克里姆林宫正式签署《俄罗斯联邦宪法》，宣布俄罗斯联邦正式成为民主国家。

1. The first step in the process is to identify the problem. This involves gathering information about the situation and understanding the needs of the stakeholders involved.

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INDIVIDUAL EFFICIENCIES OF MAGNETIC
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IN MAGNETIC FIELD ($\omega_0 = 10^{-10}$).

PHYSICAL EFFECTIVENESS OF WEAR
INFRA-RED-FREQUENCY ELECTROMAGNETIC
FIELD. 1757

PHYSIOLOGICAL EFFECT OF
ELECTROMAGNETIC FIELDS. A CRITICAL
REVIEW. SUBD

TOXICOLOGICAL EFFECTS AND MEDICAL APPLICATIONS OF RADIOFREQUENCY ELECTROMAGNETIC FIELDS. 1974

BIOMINERALIZATION EFFECTS OF MICROWAVE AND
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UNITED STATES ELECTROMAGNETIC SILENCE ACT
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1. The first step in the process is to identify the problem or issue that needs to be addressed. This involves gathering information and understanding the context of the problem.

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 2. 1995-1996 年，中国对日本进口货物中，机电产品占 40.2%，高新技术产品占 10.1%，农产品占 10.1%，纺织品占 10.1%，其他产品占 29.5%。
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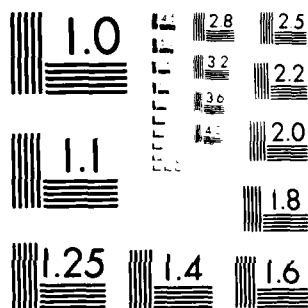
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